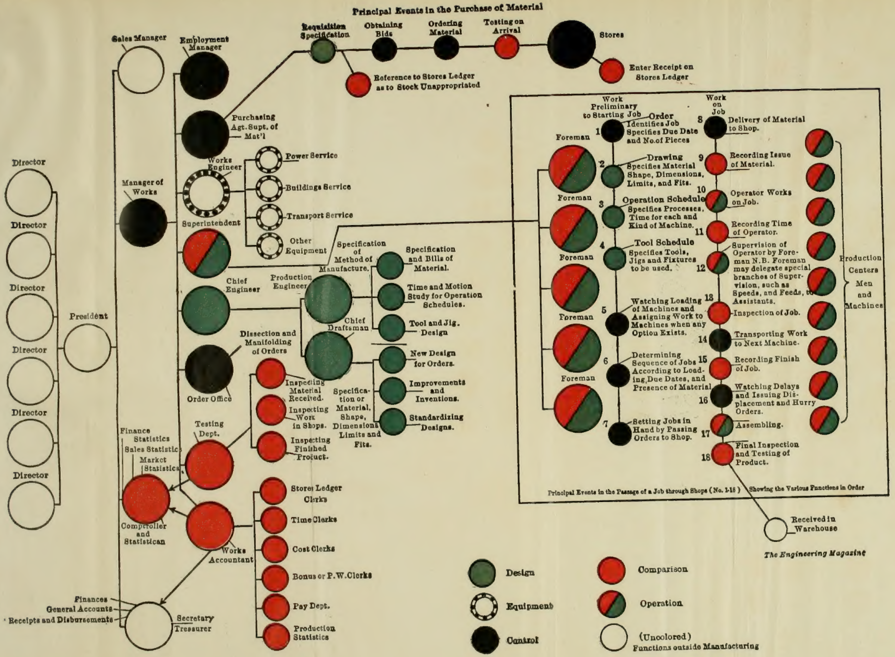

DIAGRAM I.—SHOWING THE DISTRIBUTION OF THE WORK OF THE ORGANIC FUNCTIONS IN A COMPLEX INDUSTRY, SUCH AS A MACHINE SHOP.

Note. To avoid confusion, only the principal features of the organization have been featured. Similarly, lines connecting the "principal events in the passage of a job through shops" with the various sources on the left hand of diagram have been omitted. The colors will, however, afford the necessary guidance.

Study of the diagrams should be postponed until after the description of the Organic Functions has been read.

Compare with Diagram II showing the Organic Functional development in a single, continuous, chemical industry.

ɪ I.—SOWING THE DISTRIBUTION OF THE ꞉ OF TI ORGANIC FUNCTIONS IN A COMPLEX STRY, EH AS A MACHINE SHOP.

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THE

SCIENCE AND PRACTICE OF MANAGEMENT

BY

A. HAMILTON CHURCH

NEW YORK
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1918

"Two tasks are set for the worker in any science. One of these is to enrich the chosen field by the discovery of new facts and the statement of new experiences. The other . . . is to arrange the facts already known in the best order and to bring out the relations between them as closely as possible. Whenever progress in the first of these tasks has been rapid, the second becomes the more necessary, for it offers the only possible way of attaining mastery . . . and of bringing the science as a whole into a convenient and serviceable form."—WILHELM OSTWALD, *"Fundamental Principles of Chemistry."*

"There has not yet been established a science of management. And yet, if a science were ever needed, meaning definite principles, based on exact knowledge of facts, it is in this very matter of management."—WILLIAM C. REDFIELD, *"The New Industrial Day."*

AUTHOR'S PREFACE

Some twelve years ago * I advanced the proposition that manufacturing activity could be analyzed into certain well-defined factors, some of which were those of manufacturing proper, and others of which were assumed by the manufacturer for his own convenience. Among the latter may be mentioned as examples the land-owning and building-owning factors, and the factors of power and light supply, all these being undertakings obviously separable from manufacturing proper and, in fact, not always being assumed by the owner of the business.

The object of that analysis was to throw clearer light on the nature of indirect expense or burden. It was found that by isolating these special factors and ascertaining their value separately, instead of throwing them into the general pool of expense, it was possible to obtain costs that were a much nearer approximation to the facts of manufacture than had been possible before. It is pleasant to record that this view of expense has been upheld and approved by nearly all recent writers on that complex subject.

The method therein applied has now been used in an analysis of the facts of manufacturing *administration*. It has been endeavored to ascertain the fundamental facts of production, *not from the viewpoint of costs, but from the viewpoint of manage-*

* See *The Engineering Magazine,* January-June, 1901, article on The Proper Distribution of the Expense Burden. Issued in book form, 1908. Second edition, 1913. Also see ''Production Factors'', published 1910. Both published by The Engineering Magazine Co., New York.

ment. Instead of trying to throw light on the nature of expense, I have here endeavored to throw light on the nature of organization. In other words, this book is an attempt to formulate such fundamental facts and such fundamental regulative principles as may be hereafter developed into a true science of management.

The question of formulating some approach to a true science of management has been in the air for some time. The first and most forceful stirring of the subject is unquestionably due to Mr. Frederick W. Taylor, whose paper on "Shop Management," issued in 1903, opened most persons' eyes to the fact that administration was ceasing to be an empirical thing—a kind of trade secret, known only to a few men—and that it was entering a stage where things could be reasoned about instead of being guessed at. Later on Mr. Harrington Emerson emphasized the human element in the problem—the mental qualifications necessary to efficiency. Unfortunately, the useful tendency thus initiated soon led to unforeseen results. The phrases "scientific management" and "efficiency" became the stock-in-trade of numberless amateurs and pretenders, the value of the movement was magnified beyond all reason, and the public were led to believe that some wonderful new and potent instrument for getting rich quickly had been discovered.

The fact is, however, that the application of disconnected ideas, however valuable in their special place these may be, does not make a science. That would not be a misfortune in itself, but it becomes a misfortune when the one is mistaken for the other, for this bars the way to real progress. In the rush *to apply,* the necessity *to construct* has been forgotten, and I believe it to be true that ten years' perience of "scientific management" has produced no new developments of importance, obviously because its elements were disconnected ideas, not by any means universally applicable.

It is probable, however, that the art of management has arrived at a stage of development where the study of its fundamental facts and underlying principles may be commenced. In the spring of 1912, in conjunction with Mr. L. P. Alford, editor of the *American Machinist*,* I undertook an attempt to reduce the regulative principles of management to their simplest terms—that is, to express them in the broadest and most general way—and thus to provide a basic classification for administrative activity on which a detailed structure could subsequently be built up. We found that all the different working principles common in manufacturing could be reduced to one of three main groups, viz.:

(1) The systematic accumulation and use of experience.

(2) The economic control (or regulation) of effort.

(3) The promotion of personal effectiveness.

These regulative principles were afterward endorsed and adopted in the majority report of the special committee appointed by the American Society of Mechanical Engineers to investigate the new systems of management—a fourth principle, namely, the "transfer of skill," being added to them by the committee.†

Following up the line of inquiry thus started, I contributed a series of articles to *The Engineering*

* See "The Principles of Management" by Church-Alford, *American Machinist,* May 30, 1912.

† See Proceedings of A. S. M. E.

Magazine (January-June 1913), in which the application of these principles was worked out. These articles were termed "Practical Principles of Rational Management", because at that time the peculiar feature of the modern system seemed to be the introduction of *reasoning* into management, as opposed to the old rule-of-thumb school. But, on reviewing the whole matter, more recently, the importance of the idea that management is based on the existence of *specific organic functions, each devoted to a special purpose,* developed more and more strongly, with the result that, though the matter of those articles has been incorporated in this book, most of it has been rewritten and a large amount of new matter has been added, dealing more particularly with the facts and laws on which every kind of manufacturing management must be considered to rest. This book has been somewhat hurriedly written in the midst of professional work, and contains many "gaps and overlaps", in defiance of the law that "Effort must be co-ordinated". The reader will no doubt observe these, and it would give the author great pleasure and assistance if any of them are pointed out to him by way of correspondence.

A. Hamilton Church.

New York, March, 1914.

Note.—Readers of *The Engineering Magazine* articles will be assisted by noting that some changes in nomenclature have been found desirable. The "spheres of activity" therein mentioned are now more properly called "organic functions", since they represent the great main *kinds* of activity found in manufacturing of all kinds. The sphere of "organization" has yielded to further analysis, and has been decomposed into two functions, namely, "Equipment" and "Control". Finally the phrase "Control of Effort" has been replaced by "Regulation of Effort", this change being purely for convenience in nomenclature, and implying no change in the principle itself.

CONTENTS

Author's Preface iii

Object of book—an attempt to formulate fundamental facts and principles of management—F. W. Taylor's paper on Shop Management—necessity for further constructive work—time probably arrived when serious study of management as a science may be commenced.

Chapter I. Introductory 1

This discussion confined to Administration problems—excludes questions of selling, distribution and finance—is confined to Manufacturing of Product—management an organic affair—definition of what is meant by organic—example from human body—correct parallel is not with organs but with functions—importance of distinguishing the Organic Functions of Management—has same relation to business management that knowledge of anatomy and physiology has to a physician.

PART I. THE SCIENCE OF MANAGEMENT

Chapter II. The Two Great Instruments of Management 10

The problem of management defined—its processes, or analysis and synthesis—over-emphasis of synthesis characterized past practice—over-emphasis of analysis threatens modern practice—steps in the development of practical analysis—time study: what it is and what it does—conditions disclosed by time study—motion study—routing of product and layout of machines—planning and despatching-system: its possibilities and its failures—synthetical methods applied to industrial management—the methods of synthesis—functional organization and grouping—the five organic functions: Design, Equipment, Operation, Control, Comparison—their characteristics and fields briefly defined.

Chapter III. The Organic Functions of Manufacturing Organization 37

Five separate varieties of Function distinguishable—Each seeks a separate end by separate means—These are: Design, Equipment, Control, Comparison, Operation—do not apply to anything but manufacturing—Organic Functions are water-tight compartments—are basic and natural divisions—consequently have independent efficiencies—raising efficiency of one Organic Function does not raise efficiency of the others—First Organic Function, that of Design, considered—is the prescriptive function, specifying intention—is the source of all productive activities—always present, but in very different degree according to the industry—its commencement and final limits—what it specifies—all specification in advance is an act of Design—its relation to operation schedules and time study—Table I, showing scope of the function of Design—Second Organic Function, that of Operation, considered—aim is to transmute material into new forms conformably with Design—What Operation comprises—is the most highly individualized function in any plant—difference between technology and management—management is the science of applying technology—but does not increase efficiency of technology—efficient management does not discover technical secrets—importance of observing this difference—Table II, showing scope of the Organic Function of Operation—Design prescribes and Operation carries out—the remaining functions are set up in practice only to assist the easier functioning of Design and Operation.

CHAPTER IV. THE ORGANIC FUNCTIONS OF MANUFACTURING ORGANIZATION (*Continued*) 63

Design and Operation are the primitive functions; Equipment, Control and Comparison are more recent developments—now equally important—The Organic Function of Equipment considered—is the function that provides conditions —has two sides, installation and administrative —the first includes arrangement of buildings, power plant, transport appliances, storage arrangements, layout, etc.—second comprises the current use of installed equipment—good conditions must be maintained as well as installed— hence the "services" of Equipment—Table III, showing scope of the Organic Function of Equipment—the independence of the functions illustrated—each separate function has its own kind of efficiency—this can be hindered but never increased by the efficiency or non-efficiency of other functions—this fact of great practical importance—The Organic function of Control considered—object of Control—together with the Function of Comparison forms the nervous system of the plant—Control is devolution of authority—close parallel with nervous system of body--all the Organic Functions represent successive devolutions, the primitive craftsman exercised them all in his own person—Table IV, showing the successive devolution of the Functions during the rise of an industry toward modern conditions—were devoluted in following order—Operation, Equipment, Design, Comparison, leaving Control as the "function of the boss" —system no substitute for executive capacity— Control is the means by which the executive sub-divides and devolutes his function as "boss" —practical terms of Control stated—Table V, showing scope of the Organic Function of Control—Control is the great organ for conducting manufacturing—The Organic Function of Comparison considered—its aim is to find how far the intentions of Design and the orders issued by Control have been realized—its measures— has two aspects dealing respectively with properties and quantities—the first is allied to Inspection, the second to Accounting—watches wastes —measurement alone useless without subsequent comparison—this frequently overlooked, leading to excessive "system"—all measurements must be compared with something, preferably standards—complex systems of Comparison useless unless Control sufficiently developed to make use of them—Table VI, showing scope of the Organic Function of Comparison—final remarks on the five Organic Functions—they represent the division of human faculty in manufacturing—are natural divisions with which organization must coincide to be successful.

CHAPTER V. THE REGULATIVE PRINCIPLES, OR "LAWS OF EFFORT" ---------------------------------- 92

The Organic Functions are set going by the application of Effort—efficient exercise of Effort requires training—particularly it requires basing on experience—all human progress is due to remembering experience of past generations—First Law of Effort considered; Experience must be accumulated and applied—In starting a plant this is usually recognized to some extent—but process must be continuous—accumulation of experience must go on—its practical application must also go on—Second Law of Effort considered—Effort must be economically regulated—in industrial matters this is too broadly stated—Regulation of Effort is therefore further analyzed—in modern manufacturing we have to do with the combined and simultaneous Effort of a collection of men—analyzing this activity, we observe that Effort must be regulated in four ways; it must be Divided, Co-ordinated, Conserved (or saved), and Remunerated—Division not difficult, but implies loss of control—therefore needs supplementing by co-ordination—Coordination the converse or antidote to Division —means the avoidance of gaps and overlaps arising from imperfect division—ensures that Effort as divided does really cover the whole field, and that it is not duplicated unnecessarily —Conservation of Effort is the quantitative principle—not sufficient to divide Effort, nor even to avoid gaps and overlaps in its application to work—too much Effort may still be involved—Conservation of Effort requires consideration of how to eliminate unnecessary Effort by employing best methods, condition and auxiliary aids —Finally Effort must be Remunerated—this principle has to do with the ascertainment of what particular direction of effort should be selected for encouragement and reward—these directions will vary in each Organic Function—it determines when and where to apply incentive—but the form of this incentive belongs to the application of the remaining Law of Effort —Third and Final Law of Effort; Personal Effectiveness must be promoted — Personal Effectiveness has, first of all, a physical basis —good physical conditions are therefore necessary and must be studied—it has also a psychological basis, individual characters and qualifications must therefore be studied—also all individuals respond to incentive—therefore forms of incentive must be studied—general scope of this law is that Quality and Quantity of Effort put forth by the individual are controllable, since they depend on conditions—these conditions can be studied and adjusted so as to extract the best results—the youngest and least developed of all the Laws of Effort—has very important practical bearings—will be the great work of future years to develop this Law more definitely—Table VII, recapitulating the Laws of Effort —their scope is to show what to look for, what precautions must be taken, what dangers should be avoided, and what advantages may be realized in the organization and management of a plant.

CHAPTER VI. PRACTICAL APPLICATION OF THE FIRST LAW OF EFFORT ---------------------------- 112

The Organic Functions represent five different kinds of aim—that is, five different applications of Effort to produce five different kinds of result—Effort defined as any kind of human activity undertaken with a definite end in view —hence the Organic Functions represent five different groups of men, each group trying to do a different thing—Laws of Effort must have definite bearing on efficiency of these five kinds of Effort—each of these groups or Organic Functions will be affected in a different way—practical application of first Law of Effort (1) in regard to Design—use of experience in organizing Design—to the experience of others we add some private experience of our own which gives individuality to our Design—(2) in regard to Equipment—we search out the best conditions for production as embodied in Equipment and adopt them—great progress of late in this respect—(3) *in regard to Control*—difficulty of selecting and applying experience in organizing this function—existing systems of Control, mostly specific or arbitrary combinations—new plants cannot have highly developed mechanism of Control—importance of trying to elucidate principles in this respect—Control must be developed as business grows in size—(4) *in regard to Comparison*—more experience available than in case of Control—Accounting and inspection methods already well developed—that is, methods are, but *what* should be recorded and *why* it should be compared at present largely dependent on personal taste—wide areas of comparison awaiting study—(5) *in regard to Operation*—more experience available in some industries than in others—in others operations largely empirical and requiring new study—Operation the most individualized function in any plant—but the first Law of Effort applies just the same—experience must be accumulated and applied just as far as it is available—(6) *in regard to running a plant*—need of recording and applying progress made by others—progress constantly being made in all the Organic Functions—ceaseless vigilance the price of progress—but this progress is of five kinds, corresponding to the five Functions—must be gathered and applied by different persons usually—great practical importance of recognizing this. Table VIII.

CHAPTER VII. PRACTICAL APPLICATION OF THE SECOND LAW OF EFFORT 130

General tendencies of Division, Co-ordination, Conservation, and Remuneration of Effort as applied to the Organic Functions—*Application of Division of Effort Considered* (1) in Design —gives rise to parts—no relation to design of product for use—design of parts often embraces that of tools and appliances, and specification of routine in Operation—processes prescribed must tally with units of Operation—what the designer must keep in view—(2) in equipment: utilization of space—layout—power plant—stores and transport—organization of "services" to maintain conditions—units of Division in regard to Equipment—(3) in Control: units of a system of Control—installation of Control—administrative side—Orders and their handling—(4) in Comparison: Comparison units are of two kinds—as to Properties—sphere of Inspection—and as to Quantities and Values—sphere of Accounting—need of clearly setting out Comparison units, since Control is greatly facilitated by so doing—(5) in Operation: Operation units are processes—general tendency towards new subdivisions—units of Design must correspond exactly with Operation units—Table Nine—*Application of Co-ordination of Effort Considered*—in all functions means avoidance of "gap and overlap"—in Design means "limits, fits and tolerances"—in Equipment means balance of Equipment and of the "services" which maintain conditions—in Control means adjustment of spheres of duty, and supplementing limitations of written Orders by Conferences and Committees—in Comparison means bringing together unit facts in a significant way—avoidance of duplication of work—in Operation means delimiting the sphere of similar processes —gap and overlap in Operation not very common, since it would stop production.

CHAPTER VIII. SECOND LAW OF EFFORT (*Continued*) 166

Application of Conservation of Effort considered—in general means guarding against waste of Effort—in Design embraces the question of transfer of skill by means of jigs—also implies standardization of parts, of tools and auxiliaries, and of stores—gives rise to the sub-principle of "fewest things"—in Equipment means shortest path of travel of Product as controlled by arrangement of Equipment—also use of conveying appliances—in Comparison prescribes the elimination of system—demands shortest path from unit fact to final statistics—in Operation means keeping machines at work—keeping technical men on technical, and not clerical, work—avoidance of fetching and carrying by operators—*Application of Remuneration of Effort considered*—in regard to the work of each organic function means the study of what particular type of efficiency should be selected for encouragement and reward—each function examined to discover these types—different objects of incentive in each. Table XI.

Chapter IX. Practical Application of the Third Law of Effort 207

Third Law considers men as human beings and not in their functional aspect—ways in which personal effectiveness is promoted—by setting up good physical conditions and environment—what are good physical conditions—a generous minimum to be aimed at—different standards for different kinds of work—inefficiency results from bad conditions—but such may escape notice—brief enumeration of more salient conditions—direct, indirect and protective—sense of proportion necessary—vocational fitness—the special field of the new industrial psychology—great caution necessary—difference between psychological analysis and motion study—case of color-blindness used as illustration—new psychological analysis not confined to elimination of unfit—will be constructive also—Prof. Muensterberg's study of vocational fitness in regard to motormen—representing facts by laboratory tests—reproducing "inner similarity of mental attitude" found in working conditions—practical verification of results—case of telephone girls—

general intelligence factor—probable practical value of the new method—but chiefly as regards routine work, not for the higher posts. Habit: value of industrial—habit somewhat forgotten of late—industrial, not ethical, standards only in question here—habit should be formed on standardized bases, old or new—motion study gives new ways of doing things—these should be standardized and passed into new habit—"written instructions" a nuisance sometimes unavoidable—should be avoided wherever possible—Mr. H. L. Gantt's work—principle applies not only to shop workers but to all men in all functions—overmuch attention focused on skill factor of late—other habit factors of great importance—must be given due weight—"Inertia" of habit—habit standards not necessarily new standards—examples.

CHAPTER X. THIRD LAW OF EFFORT (*Continued*) 241

Esprit de corps—definition—includes "group-pride"—arises from personality—its great value—therefore must be fostered—what gives rise to it—essential features, among which is belief in purpose for which group is organized—in industry means product—excitement of propaganda—industrial conquest—provides stimulus already used in salesmanship—needs applying more widely—*esprit de corps* is synthesis of the good-will of individuals—is a moral force, thus cannot be brought about by mechanism—difference from enthusiasm—is a steady force—based on a common interest—therefore men's interest and imagination must be aroused—can be applied to small groups—examples—team-work and co-operation not the same as *esprit de corps*—which gives rise to them—workman's idea of what constitutes a "good shop."

CHAPTER XI. THIRD LAW OF EFFORT (*Continued*) 259

Incentive—must be proportioned to the Effort required—definitions—what incentive rests on—may be material or moral—various questions asked about it—Incentive can be overdone—the sociological Law of Average in Faculty—existence of grades—individuals rise or fall, but grades remain—incentive must correspond to grades—relation to "customary wages"—the latter the result of long experience through years and generations—incentive must develop faculties that exist ready for development—its field is not to raise grades—practical bearings of this distinction—Emulation—must be used to foment interest—examples—group incentive independent of, but may be alongside, bonus—appeal to different kinds of self-interest—incentive must have two aims, combined—definition—case of power-plant considered—analysis and synthesis—incentive in operation its most discussed side—points of view about time and motion study—profit-sharing—its advantages and defects—labor does not alone produce wealth—Table XIII.

Chapter XII. The Manager and the Instruments of Management 280

Production is a synthesis of functions—always present but not all equally developed—sometimes quite rudimentary—how is synthesis to be effected—influence of strong personality—leadership essential to great results—manager is outside science of management—must use its principles, as chemist is outside the science of chemistry and uses its principles to effect his aims—management science provides the instruments, their successful wielding depends upon capacity of manager—*Résumé* of Functions and Laws of Effort.

PART II

PRACTICAL ORGANIZATION OF THE ORGANIC FUNCTIONS

Chapter XIII. Organizing the Function of Design 299

The first step is decision on product to be manufactured—next step is selection of design—practical operations begin with organizing drafting-room force—next follows analysis of product into components suitable for manufacture—manufacturing processes require division of effort and co-ordination of effort—economy of manufacture requires conservation of effort—the necessary records of components and tools, or the "Book of the Plant"—symbolizing—specification of material—specification of details of operation—organizing the production-department force—establishment of standards—the remuneration of effort or incentive to efficiency—conclusion—Table XIV, showing applications of analysis to the function of Design.

CHAPTER XIV. ORGANIZING THE FUNCTION OF EQUIPMENT ---------- 318

The installation of equipment—proportioning equipment — balancing equipment — arranging equipment—standardizing conditions of manufacture—organizing the equipment service—remuneration of power, building-maintenance, repair and cleaning forces—conclusion—Table XV, applications of analysis to Equipment.

CHAPTER XV. ORGANIZING THE FUNCTION OF OPERATION ---------- 330

The functional operation defined—consists of synthesis of processes, trades and skills—it is the actual technical work performed on material to change its status—technical and administrative aspects of the accumulation of standardization and experience—standardizing processes of operation—general ignorance of attainable standards of production—possibilities of establishing unit standards of output—fixing total productive capacity—a load factor of idle time—division and co-ordination of effort in production—remuneration of productive labor—conclusion—Table XVI, applications of analysis to the processes of production.

CHAPTER XVI. ORGANIZING THE FUNCTION OF COMPARISON ---------- 347

The foundations of success in executive management—relations of accounting to the executive—the problem of overhead burden—inspection, one of the first functions of comparison—records of productive and non-productive labor and time—statistical systems and departments—remunerating the inspection, time-keeping and cost-keeping forces—conclusion—Table XVII, application of analysis to the function of Comparison.

CHAPTER XVII. INSTALLATION OF FUNCTION OF CONTROL 359

This function plans the duties within all the other functions—administering the function of control—the mechanism at work—analyzing the duties to be performed throughout the plant—determining ranges of responsibility and authority—co-ordinating duties through conferences or committees—co-ordinating the line and staff—controlling the movement of materials, the movement of instructions, and actual operation—things which may be fixed in advance—establishing habit—determining specifications—stock-keeping—time-setting for material movement—move orders for work—despatching work—Table XVIII, applications of analysis to the function of Control.

APPENDIX I 397

THE LABOR QUESTION

APPENDIX II 427

THE EXPENSE BURDEN IN RELATION TO PIECE WORK AND PREMIUM

APPENDIX III 457

THE EXPENSE BURDEN IN RELATION TO BONUS

APPENDIX IV 483

THE PLANNING DEPARTMENT

APPENDIX V 509

SOME AXIOMS OF ADMINISTRATION

THE SCIENCE AND PRACTICE OF MANAGEMENT

BY

A. Hamilton Church

With an Appendix on Systems of Wage Payment
and
two folding diagrams in color, showing practical organization by organic functions in two types of plant

SCIENCE AND PRACTICE OF MANAGEMENT

Chapter I

INTRODUCTORY

IN any industrial undertaking there are two elements present, which though sometimes merging into each other, and always exerting reciprocal influence, are nevertheless quite distinct in their essence. The first of these is the Determinative element, which settles the manufacturing *policy* of the business—what to make—and the distributive *policy*—where to sell and by what means. The second is the Administrative element, which takes the policy as determined, and gives it practical expression in buying, making, and selling.

Of these two elements, which are not infrequently combined in small businesses, the first — the Determinative — represents the higher and scarcer faculty. The larger the business the more difficult will it be to obtain men capable of adequately filling the exacting demands for judgment, foresight, courage, and experience which decision on large points of policy sets up. The danger in vast organizations commonly lies not in any prospective failure on the side of the Administrative element, for in this department the assistance of all kinds of experts can be obtained; errors, moreover, are of less vital consequence, and their results can be more quickly reduced to safe proportions. It is failure in the Determinative element that pulls down flourishing businesses. When the general of an army blunders, it may easily neutralize the army's efficiency as a fighting unit.

The time has, perhaps, not yet come when we may reduce the Determinative element to a body of principles, or even working rules. It contains, today, too many unknown and variable factors. This book, therefore, makes no attempt to deal with this aspect of industry; it covers the element of Administration alone, and only one division of administration, namely, manufacturing. The administrative problems of Selling and Distribution are excluded from consideration in its pages.

Some twenty-years study of the manufacturing problem has necessarily resulted in modification of the author's views on the subject at various periods, but this study has been for a long time accompanied by a growing acceptance of the view that management, or rather administration (eliminating the determinative element), is an *organic* affair. It is this view that will be expanded in this book.

It may be desirable to explain in some detail just what is meant by the term "organic". The analogy of the human body gives the simplest illustration: the work of the great and lesser "organs" of the body, the heart, lungs, brain, etc., is independent yet co-ordinated. One of these organs may be working at a higher efficiency than the others, or *vice versa,* but on the balanced working of the whole set depends the health of the man, and his efficiency for whatever he wants to do—riding, walking, writing a poem, or dictating a business letter. Some of these organs may fall into a state of inefficiency without marked results being at once visible, or again some one of them may be permanently lowered in efficiency without hindrance to particular kinds of work. But with each there is a point beyond which organic inefficiency cannot go without disaster.

Further, we have the nervous system of the human body. This is, amongst other things, the co-ordinating mechanism of the various organs. Injury to this is the most serious kind of disaster. It is also interesting to note that the nervous system embraces ganglia or subordinate automatic little brains, to which are entrusted certain routine performances, so often repeated as to be unworthy the recurrent attention of the central brain every time they are put in use. In learning to ride a bicycle, for instance, the central brain is at first very actively engaged in giving orders to the unwilling limbs. But as the new motions are made familiar by repetition, their ordering is turned over to the ganglia concerned and they become automatic. When mounting a bicycle in our earlier stages we think about our movements with very close attention. Later, we jump on and ride off, thinking the while of almost anything else.

This process of education of the subordinate ganglia affords an explanation why all instructors in any kind of manual or mental activity harp continually on commencing in the right way from the first. If we confuse the nervous system with wrong impressions, we never succeed in entirely eliminating the necessity for more or less attention of the central brain to what we are doing. Applied to administrative problems this is a parable that will throw light on unhappy conditions we have all met. Places where the management is always fussing over the mistakes of subordinates are places where the subordinate ganglia have failed to acquire proper habit.

It is not intended that this analogy should be pushed too far, or that an exact parallel should be drawn between the factory and the body. The human organism is a structure vastly more complex, and has duties far more varied, with adjustments far more refined than the largest industrial concern. Beside such an organism, the most complex factory system is an affair of almost transparent simplicity, and we might say, coarseness. But it is from the fact that the human body is the most highly co-ordinated and efficient mechanism with which we are acquainted that we may expect to find helpful analogies and even practical hints.

Thinking along these lines, the author's attention was given to determine, if possible, what organic elements were to be found in industrial activity. It was tempting, of course, to apply the idea to specific things, to see the heart in the shop full of machinery, the liver in the stores department, the lungs in the power equipment and so on. But this was found to lead nowhere. The true line of advance was seen to be in an analogy with the *activity* of organs, not with the organs themselves. And, of course, that activity is of a totally different kind in a factory to anything in the human body.

We do not find, then, any close physiological analogies between the body and the factory. What we do find are groups of activities common to all industry, which groups are *organic;* that is, they perform specific functions in a specific way. Like the organs of the body, they are independent, yet closely co-ordinated. As in the biological field, we find instances where certain of these organs are purely rudimentary, and yet quite adapted to the wants of the whole. We find also that the efficiency of one organ is not related directly to the efficiency of another, and only to the efficiency of the whole in unequal degrees. Finally we do find something closely analogous to the brain, and the nervous system with its subordinate ganglia.

It may be asked what is the practical value of reducing administration to a set of organic functions* and regulative principles or laws? To those who demand an immediate cash value for every effort of thought and attention, it may be pointed out that this kind of knowledge bears the same relation to the conduct of a successful business that a knowledge of anatomy does to the successful practice of a physician. In the days when medical men were ignorant of the structure of the body, of the functions of its organs, and of the various physiological principles that con-

* It may be desirable to point out that the five great organic functions treated of in this book have no relation to what is termed "functional foremanship". It has been found that *all* manufacturing activity is functional in the broadest sense. Functional foremanship is merely a special case of the division of effort applied to other matters than direct operative labor or "processes". The wide interest excited by "functional foremanship" was probably due to the fact that division of Effort had been hitherto associated chiefly with manual labor. "Functional foremanship" is applicable in some industries, but not in others. The organic functions are common to all industries.

trol human life, the practical art of medicine was at a very low ebb. It was compounded of guesswork, quackery, and assurance in about equal parts, and generally amounted to the doing of something at random with an air of great wisdom. But withal the patient frequently died, where modern medicine would easily have restored him to health.

It is not only in regard to increased control over the diseases of business that a knowledge of the anatomy and physiology of administration has immediate practical value. It has equal value in another direction, a direction that has no counterpart in medicine; for a physician never puts the parts of a human body together. The business man, on the other hand, is very frequently called on to put the elements of a business together, or in other words, to start a plant. And how many failures result from plants being started in violation of every principle of administration it is not easy to say, but one may guess that failures from this cause are not uncommon. At any rate many unhealthy weeds result, that should have been vigorous dividend-bearing perennials.

The immediate, practical, value-yielding return from an analysis of administrative functions may therefore be expected to be considerable. If the analysis is a happy one it will immediately show natural lines of development, natural groupings of the different kinds of skill concerned, it will indicate Why and When, and will also throw light on limitations—how far, for example, certain instruments or tools, such as time study, or inspection, should be employed; and it should do this, not by hard and fast rules culled from some one person's practice in one particular plant or industry, and never wholly applicable to other plants or industries, but by application of universal rules, in the sense that rules of arithmetic are universal.

CHAPTER II

THE TWO GREAT INSTRUMENTS OF MANAGEMENT

THE problem of management, broadly regarded, consists in the practical application of two great intellectual processes. Whatever the end aimed at, whether the conduct of a military campaign or the manufacture of an industrial product, the processes involved are those of *analysis* and *synthesis*. In proportion as analysis is keen and correct, and synthesis is sure and unerring, so will be the resulting efficiency. If our power of synthesis is less than our power of analysis, academic and theoretical "systems" will result. If, on the contrary, we neglect analysis and force synthesis without having shrewdly studied our ground, some, and even considerable, practical success may result, but there will be a great waste of opportunity and failure to attain the most efficient results.

The neglect of analysis and the forceful use of synthesis are typical of the successful businesses of the past. The strong, shrewd, "practical" man could afford to neglect a careful analysis of his problem, because he had a very large margin of profit to draw on. His wastes were great, his lost opportunities many, but he knew nothing about them and cared less, because his operations were successful in proportion to his expectations. If his profits were not, as we can see now, as large as they should have been, they were at least as large as those of everyone else.

During the last fifteen years there has been a considerable development of the art of analysis in the problems of management. The early beginnings of this movement were characterized by a desire for more exact knowledge. It began to be realized that manufacturing is, in fact, made up of a long series of very small steps, and that it is desirable to ascertain the money value of these steps, so that comparisons may be made. In this way the movement towards cost accounting began, and presently reached a high state of development.

The next step on the path of development of the practical use of analysis was due to the desire of employers of labor to find some satisfactory basis for rewarding it according to results. The old piece-work methods were largely based on the hit-or-miss plan. Some more or less experienced foreman or rate-setter came along and looked at a job, and made what appeared to be a guess (often a very close guess) at the time that should be taken to perform the work. A rate was fixed accordingly. The introduction of the premium plan with the widespread notice it attracted, emphasized the need for more accurate determination of times, and as this happened in the machine-shop industry, which is of all industries the most complex and varied both in its machines and its product, it was found that some new departure was needed.

To meet this need, the particular kind of analysis now known as "time study" was rediscovered. As far as the machine industry was concerned it appears to have been new, but the idea is really old, going back to the very beginnings of the factory system. The principle of time study is, in essence, the analysis of something into its elements, and observation of the times taken by a skilful operator to perform these elements. By adding the times together, it is possible to get a very close approximation to what may reasonably be considered the standard time for the whole job.

This, of course, is merely doing systematically, and in an exact way, what the foreman or rate-setter did mentally and by the aid of his experience. Such a man did not really guess at the proper time. He rapidly ran over in his mind the successive steps to be taken, and pictured them to himself, allotting the proper time to each, and thus arrived at a result. The difference between his work and that of a time-study man was, chiefly, that he gave the answer but did not disclose the workings. The latter records every detail of the way in which he arrives at the result, with the obvious advantage that criticisms and corrections may be made, and even the details themselves may be of importance for future reference.

To understand what it is that time study, as an instrument of analysis, really does, we may suppose that a man undertakes an odd kind of journey for a bet. He undertakes to run three miles, walk five, swim half-a-mile, ride a bicycle two, crawl one, and hop half-a-mile, finally ending up by taking an aeroplane and flying six miles. And he undertakes to do all this within a given time. Now to look at the problem as a simple matter of travelling eighteen miles will not give us a good idea of the possible time it will take. If we are to make a wager with him—if, for instance, we are to give him fifty dollars if he completes the journey within a certain limit of time—it is obvious that we shall be in a very unsafe position if we do not carefully analyze each of the different kinds of progression that he has to make, and reckon up his probable speed as regards each.

If, on the other hand, we make a list of the different kinds of movement he has to make, and apply our experience to assess his possible speed in each kind, and then aggregate the items, we shall be fairly close to a "sporting chance". But if we happen to have at hand trustworthy data of record speeds in each of these different kinds of movements, then we shall be able to make a very close wager, and it will depend on the man himself whether he rises to the occasion or not.

Time study, as applied to jobs, works exactly in this way. It applies itself to discover, first, exactly what different kinds of work are involved in the production of a piece. Then it proceeds to observe and record, step by step, the exact time taken to perform each of these different kinds of work. Some of these times may be referable to standards already known, and some not, but in any case the aggregate of the different kinds of work as expressed in minutes or seconds gives a close approximation to a correct time, on which we can base our offer to the man. The analysis of work by means of time study is in many cases very valuable, but like all intellectual instruments its employment can be overdone, if it is erected into an end in itself.

The observations made by time study very soon disclosed the fact that great inefficiencies existed in and between these various kinds of work which are involved in production of a given piece. To employ another analogy, we may regard time study as a microscope which is applied to ascertain the structure of a unit process which has heretofore been regarded as a whole, indivisible thing. When the unit productive process was subjected to the lenses of the time-study microscope it was found to be full of faults. Instead of being a smooth, homogeneous progression from beginning to end, it was found to consist of knots and burrs, rough surfaces, impulses starting here and reaching nowhere, efforts begun and broken off without effecting anything, and generally to be different from what everyone thought it to be.

From time study to motion study (itself also a method of analysis reaching back to the early beginnings of the use of machinery) is a natural step. Having ascertained that unit processes are in fact made up of a series of steps, and having recorded these steps and allotted times to them, it was a natural development to apply criticism to the steps themselves. Why should this be done, and why that? Why should the man bend down to pick up the material rather than the material be lifted up to the man? Why? indeed! The moment questions of this kind got into the air, it very soon became thick with them. The work of Mr. Gilbreth on motion study must be regarded as the most original contribution to the science of management that has yet been made.

So far we have been considering the instrument of analysis as applied to the individual piece or component, or to use a convenient but unbeautiful word, to the job. Once, however, that analysis set out on its career, its sphere of action steadily widened.

Just as the job is made up of small steps which it was the work of time study to analyze and tabulate with time as an element, so the aggregation of many jobs, that is the product in abstract, passes through a number of stages which are also possible of analysis. Just as in operating on the job we may do this before that, and then find that we have to turn back to rectify some omission, so in creating a stream of product through the plant it is quite easy to have it cross and recross, turn back on its tracks, make sudden lunges in this direction and in that, now hurry forward and now move sluggishly, sometimes accumulate in masses, and sometimes be absent where its presence is needed —all these troubles may exist without anyone being alive to them or at least to their extent and importance, until the instrument of analysis is applied to the problem.

The routing of product and the lay-out of machines is, then, a further development of the instrument of analysis that has very important bearing on efficiency. It is of course nothing novel. New plants have always given some attention to the matter. But its exact study, its investigation by charts and diagrams, the adaptation of buildings to special agreement with their uses, the careful scrutiny of methods of transporting product within the plant—all these are very modern applications of the instrument of analysis, which are having important economic results.

Lay-out of machines and its influence on the routing of product is, however, a matter of providing conditions. We have still a large field left for the exercise of the analytical faculty in regard to the daily and hourly movement of product. Product does not move by itself in the majority of industries. Even in "continuous" industries there are places and times when human agency must be relied on, but in mechanical industries product is absolutely inert. It has to be moved. Moreover, not only has the product to be moved, but in a large class of cases when it is brought face to face with the appropriate man and machine, it cannot be worked on until specific instructions are received as to what is to be done to it. All industries are not situated thus, but most machine-shop industries are—drawings and instructions are as necessary as the material itself.

It is evident that all this activity—the separate kinds of effort involved in acquiring material, bringing it into storage, moving it from place to place at the right moment, providing drawings and instructions, communicating them to the persons concerned, testing the product, and getting it out of the plant by a given date—involves a large number of steps, in any of which considerable inefficiency may exist without any more noticeable result than a general sluggishness of working, which in its turn may have come to be regarded as the natural condition in the plant. It is obvious, therefore, that here is a field for the instrument of analysis in which important laurels may be expected to be gathered.

The modern name for the organization which is, or should be, built up on a thorough analysis of the different activities concerned in the movements of material and instructions, varies according to the fancy of the user. By some it is called "planning," by others "despatching," but by whatever name it is known it has always been in existence in all plants from the beginnings of the factory system, for the simple reason that business could not be done without it. The only difference between modern types of planning and the older practice is that, today, it is recognized as a subject of analysis, and that the planning department, or by whatever name it is known, is not merely a haphazard outgrowth of the business, but is organized after a careful analysis of the needs of the plant, with special reference to the kind, urgency, and aim of the operations carried on.

The important point in the arrangement of a planning department is not the adoption of any particular variety of organization in it, for such varieties are as many as there are separate industries, and even in the same industry there is probably no part of the system which needs such careful individual adaptation to the particular plant as the planning department. The really important point is the correct and exhaustive application of analysis to the actual facts of the case, that is, to the nature of the product, of the machines, of the men, and of the officials. Only when these facts are exhaustively known, may the design of a planning department commence.

In the foregoing paragraphs we have considered the principal applications of the instrument of analysis as found in modern industrial management. Whatever progress has been made in the past decade or two is due principally to the revival of this important instrument and its application to some of the most pressing problems of management. But there is one thing that must not be overlooked. Analysis is not a constructive instrument. We can make nothing by its aid. It distinguishes, it provides very accurate knowledge, it eliminates, but it does not build. That is the task of synthesis.

Important practical matters hang upon this very vital distinction. The modern movement toward betterment has had a somewhat chequered history. We have heard of successes, but we have also heard of failures. Why is this? If new and improved methods are to be had, there should be no failures. That they have happened would seem to show that the new methods, so far from being based on the rock of science, are to some extent empirical themselves, like the methods they seek to displace. Even so, they may be a distinct gain, because they may be much less empirical—the hits may be vastly more numerous than the misses.

Personally I have sufficient confidence in the progress that has been secured to affirm that there should have been no failures, and if there have been such, it has been due to a want of perception as to the real place of these new developments of analysis in the sum-total of management. It is the unfortunate proclivity of inventors to magnify their inventions, to look with dismay on any attempt to vary and adapt them, and especially to declare that they are incapable of improvement in any sense whatever. Now most of the new methods that have attracted public attention in recent years have been applications of analysis. And with most of them, their sponsors, perhaps unconsciously perceiving that analysis was not a constructive instrument, have welded their grain of truth into an overwhelming mass of "system", much of it entirely superfluous and arbitrary, and none of it applicable to industry at large, but only to some extent to a particular industry.

The failures that have happened have not been due to applying the grain of truth, but to applying the arbitrary combination forming the "system" to uses for which it had not the least applicability. To try to run a shoe factory like a steel works, or a chemical industry like a machine shop, is foolish and bound to fail, not because the instrument of analysis is not just as useful in one as in the other but because the synthesis of these different kinds of industry is wholly diverse.

What then is synthesis? What kind of activities are grouped under that head? In what does it differ from analysis, and in what practical ways is it applied? These are interesting questions and will be briefly discussed.

Just as analysis is the art of separating and dissecting, so synthesis is the art of combining. As a practical art it naturally precedes analysis, or more correctly it precedes *conscious* analysis. While the elements of a problem are simple, the mind, intent on its aim, analyzes unconsciously to a degree sufficient for its needs. But in proportion as the number of elements grows—and in modern industry they have grown to a very large number—then conscious analysis must be brought into play, *not to supersede but to supplement* the operations of synthesis.

The art of management up to a few years ago was wholly carried on by synthetical methods. In the industrial sense, synthesis is the combination of the faculties of men—that is, their capacities to do work of various kinds, with material—that is, with some object on which different kinds of work could be performed. *Nothing whatever of the necessity for employing the synthetical method has been removed or superseded by the introduction of analysis.* The old management has not been improved out of existence. It has not been even diminished in importance. It has only been given a new tool or instrument—an instrument of study, a microscope, something by which the true inwardness of problems may be searched out, instead of having to rely on their surface appearance and their face value. The old problems of management still remain problems, still require synthetical solution, but the chances of their correct solution are greatly aided by the modern uses of analysis.

The main distinction between synthesis and analysis in this connection is that synthesis is concerned with fashioning means to effect large ends, and analysis is concerned with the correct local use of given means. The view taken by synthesis is a wide and comprehensive one; it surveys the whole field of action; its great task is to determine "what to do". The view taken by analysis, on the other hand, is a narrow and limited one; it concerns itself with the infinitely small. Its task is to say "how to use certain means to the best advantage". Analysis builds up from the deeps, as the coral plant builds up to the surface of the ocean, not knowing whether it will come out in the midst of a navigable strait or in a backwater or bay. It does not concern itself, for it does not have to, with the ultimate fate of its work. It may work laboriously today on some problem, which tomorrow the necessities of synthesis may sweep out of existence. It will as cheerfully make a time study of a job that is never to be repeated, as of a job that is to be repeated every day for a dozen years. But the synthetical side of management demands that every effort of analysis, like every other effort made in the plant, shall have some proportion, some definite economic relation to the purpose for which the business is being run.

The method of synthesis is to combine functions, that is, specific kinds of aim, in such a way that their co-operation produces some distinct and useful result. It is important to notice that industrial synthesis *is not a mere combination of men,* it is a *combination of grouped activities or functions.* It sets up a group of activities here, such as a power plant, and another there, such as a power-press shop, and even though a man may be working today as a stoker and the next as a machine tender, it is not only the man that has been transferred,—*the direction of his activities has been changed also.* To paraphrase a famous saying, we may assert that "men may come and men may go, but the function goes on for ever". It is evident therefore that the study of functions is of the greatest importance. But functions are a product of synthesis—analysis would never organize them nor coordinate them.

Not only industry but all organized effort is functional. By this is meant that what we really do in organizing a number of men to attain a given end, is to group them under certain kinds of activities. Thus an army has its fighting force, its transport corps, its recruiting force, its medical corps, its general staff, and so forth. Each of these is made up of numbers of men, but their functions are quite different. The fighting force fights, but does not tend the wounded; its medical corps, on the other hand, never takes any part in the fighting; the general staff directs the policy of the campaign, but does not mingle in the battle. An army, in fact, is a combination of functions, quite distinct from each other, which are never confused or mixed together. Even though on occasion a man is transferred from one to another of these organic functional groupings, the nature of his activities is changed at the same time.

All these different groups are syntheses; that is, they are combinations for a particular purpose. Within each there are smaller groupings; thus the fighting force is made up of infantry, cavalry, artillery, airship corps, engineers, and so forth. And finally at the bottom we have the private soldier, or enlisted man, capable of doing only a few things, but of doing these with reliability and precision. Beginning analytically we should start with the fighting man as the unit. We should study him, his arms, training, and the variety of things he can do in a military sense. But in beginning synthetically we should not take this point of view. We should first ask what was the objective of the whole organization. We should ascertain that it was war, and then what kind of war. At home or abroad? In flat or mountainous country? Near the base or far away from it? In short, we should begin, not by studying means, but by studying ends or aims.

Thereafter we should proceed by erecting groupings successively less and less comprehensive. Having arrived at the idea of an army, we should next consider its great functional divisions, and the proportion they should bear to each other. We should see that fighting, transport, medical, and other functions must be provided for, and further considering the first, that the fighting force must have such and such proportions of cavalry and artillery to its infantry. In this way we should study the problem from the point of view of providing certain functional means to arrive at a given end, and it will be evident that this point of view has very little in common with the analysis that deals with minute adaptations of existing methods to a small, definite, and near-by objective.

In a manufacturing industry, according to the writer's examination of the subject, the objective of the whole, namely, production, is realized by a synthesis of five organic functions, which are invariably present in every type of industry, but to very different extent in each, just as an army may require a great development of transport or it may not. These five Organic Functions are Design, Equipment, Control, Comparison, and Operation.

No form of activity exists in a manufacturing plant *for the purposes of production* that does not come under one or other of these functional divisions. Consequently we can say that production is a synthesis of Design, Equipment, Control, Comparison, and Operation.

Taking the first of these Organic Functions into consideration—that of Design—it will be obvious that this must exist in every industry, but in very different degree of development in some compared with others. In a chemical industry, for example, it exists in a very elementary form, that of a mere formula of mixture. In an electric manufacturing or a heavy engineering plant, on the other hand, it exists in the most highly developed state; it demands an elaborate equipment, a large staff, a collection of experts, a close and continuous touch with every detail of life in the shops. But the important point is that both the elementary and the highly developed condition in which we find this function have exactly the same end and aim, namely, that of prescribing in advance the changes which shall successively take place in material.

Again, the nature of the Equipment, and the method of its employment, may be entirely different in a paper mill, a foundry, and a soap factory; but yet each must have equipment, and in each certain laws as to the use of such equipment must be observed in the same way. In each there will be a lay-out more efficient than any other, in each there will be decay and replacement of equipment, depreciation, maintenance and repair, etc., quite irrespective of the kind of equipment or its uses. On the other hand, the lay-out of equipment will be much more important in some industries than in others. Product that can be pumped through pipes, or conveyed on endless bands, is much more independent of physical lay-out than one which demands great effort to move it even a short distance. Every variety of equipment will have its own problems, but a large number of these problems are common; that is, they differ in degree and not in kind. But in no case is equipment absent altogether.

The function of Control is also obviously common to all manufacturing plants. Broadly stated it is the function of the "boss". But as the boss cannot subdivide himself, and cannot attend to all the matters necessitating control, this function requires more or less development according to the industry. In some, such as continuous industries where product is subject to a fixed and unvarying sequence of manipulations wholly conditioned by the nature of the machinery employed, control does not need great elaboration. In other industries, such as engineering manufacture, the multiplicity of processes and parts, the necessity of storing, handling, and moving innumerable articles of product, the importance of taking care of the element of delay, the necessity to co-ordinate instructions and material so that one does not have to wait for another, means a high degree of elaboration of the function of control, and it is consequently this function that commonly gets over-organized and smothered under folds of red tape. But no industry exists in which control does not need intelligent organization on its own merits.

Similarly, there is no industry in which the function of Comparison does not exist. In "continuous" industries, where what is being done today at twelve o'clock will be done tomorrow at the same hour, comparison is at its lowest development, though even here there are often analyses to make, temperatures to watch, operatives' attendance to check and so forth. For comparison deals with the record of quantities whether such quantities are expressed in time, money, degrees, levels, or other notation. It therefore includes testing, inspecting and cost accounting. Any data which are of significance at all, are only so by *comparison*. This comparison may be with previous or future work of the same kind, or it may be with standards. And such standards, again, may be specified standards set up by Design, such as limits, fits or dimensions, or may be comparisons between time allowed for a job, and time taken, or may deal with physical standards such as temperatures, pressures, degrees of vacuum, specific gravity and so forth. But all these cases postulate two things: (1) the observation and record; (2) something by which to judge the value of the observation and record. No industry is without need for some of these methods of comparison, while in many industries a very considerable development of the function is both proper and profitable.

The final Organic Function found in manufacturing is that of Operation. This comprises the exercise of manual skills, trades, and callings, usually by way of operating machines, but not necessarily so. Just as the prime organic function of an army is the fighting corps, so the prime organic function of a plant is that of Operation. Just as a transport corps will not win battles, though it may lose them; so the organic functions of Design, Equipment, Control and Comparison will not make an ounce of product, however well arranged, though if badly arranged they may lose the battle of competition very easily indeed. Operation is definable as the act of changing the status (that is, the form, dimension, or composition) of material in accordance with the specification of Design. In practical language it is the work of the shops, but only the operative work of the shops. It does not include foremanship, which is part of Control; or inspection, which is part of Comparison. It goes without saying that Operation is a function present in every plant of every kind.

Having thus briefly reviewed the organic functions of manufacturing, we may revert to the question of synthesis *versus* analysis.

From what has been said about the latter in the first section of this article, it will be seen that the instrument of analysis does not either help us to perceive the existence of these organic functions or tell us how to combine them so as to give rise to product. But when they have been recognized, the place of analysis is very clearly seen in relation to them. It is, in fact, an instrument employed by all of them to resolve their peculiar problems. It is synthesis, however, that teaches us to combine them, and therefore gives primary rise to results.

Industrial synthesis may be defined as the proportioning of means to ends. Analysis, in the same sense, is the study of the adroit use of certain specified means in the most efficient way. The difference is that in analysis we assume the means are as they are. In synthesis it is the choice, the relative effectiveness, the right proportion, the right kind of means that is in question. Synthesis is the physical, analysis the miscroscopical examination of the problem. Synthesis chooses and combines, analysis discusses and reveals. It is evident that we are here in presence of two processes that need to complement each other.

The art of managing an industrial plant so as to effect production most efficiently must be recognized therefore as consisting of two parts. First, the right use of synthesis—determination of the kind of organic functions needed to be set up, their due proportion, their proper balance, and their internal organization; and secondly, the right use of analysis—the investigation of the minute steps, the small stages by which product advances from stage to stage from the status of raw material to the status of finished goods. Of these two parts, the correct use of synthesis is by far the most important, as will be understood when it is realized that the systematic use of analysis is only now being introduced into industry. All the not inconsiderable triumphs of industry in the past were realized with a trifling use of analysis, and that mostly instinctive and unconscious.

To sum up, we may say that the science of management has undergone no revolution, but it is in the position of having acquired a powerful new instrument of research into its problems, namely, systematic analysis. On the other hand, the need of correct proportioning and adjustment of its functional activities today is no less, and perhaps is greater, than it ever was. To suppose that analysis is a *method* of management instead of an instrument of management is a fatal error, that has been becoming rather common of late. It seems desirable therefore to emphasize its due place, and to recall the fact that the results of synthesis remain those by which management will be finally judged in all cases.

Chapter III

THE ORGANIC FUNCTIONS OF ADMINISTRATION

EVERY administrative act arises from an aim or desire to do something. Examination shows us that five separate varieties of aim are distinguishable in manufacturing administrative work, and that this analysis is exhaustive, *i. e.,* no aim or end exists in manufacturing that cannot properly be assigned to one of these categories.

Each of these separate aims should have, normally, its own separate organization for bringing about the results it seeks, and each may therefore be regarded as a true type of Organic Function. These functions have already been enumerated as follows:—

1. Design, which *originates.*

2. Equipment, which provides physical *conditions.*

3. Control, which specifies duties, and which *orders.*

4. Comparison, which measures, records and *compares.*

5. OPERATION, which *makes.*

These organic elements of administration are specific functions and not things. They are elemental facts; not tangible entities, but facts of observation. Thus they imply different kinds of mental activity. The art of organization consists in entrusting these different kinds of mental activity to the right persons, and in supervising their co-ordination. It is very important, therefore, that the scope and limits of each function shall be as sharply defined as possible.

The object of this classification is not to provide a mere nomenclature. On the contrary, if our analysis is really correct and exhaustive, it becomes indicative of lines that must be followed rigorously, if we desire to have a thoroughly efficient organization. It should, however, be clearly grasped at the outset that these organic functions are those of manufacturing administration only. They do not apply to the erection of a bridge, or the management of a railroad, or to commercial operations such as selling and finance. They apply to the routine activity of a manufacturing plant in regard to its internal affairs only. Other kinds of administration, say railroad management, would have different organic functions from these.*

The practical value of distinguishing between these organic functions rests on the fact that they are independent of one another. They form, to use a familiar simile, "water-tight compartments". Efficiency in any one function is independent of efficiency in any other. If our Comparison is weak, speeding up Operation will not mend it. If Design is inefficient, perfecting the system of Control will not make it any better. If Equipment is at fault, we cannot remedy this by tuning up any other function.

This is evidently a very important matter to understand. These organic functions (if correctly stated) are obviously basic and fundamental divisions of manufacturing activity. They form *natural* lines of organization to which all manufacturing organization *must* conform, irrespective of the taste or will of the organizer. Consequently, it follows that those organizations that conform to these primary elements in the most simple, the clearest and the most direct way,

* Though railroad management is often called "manufacture of transportation" the phrase has little to recommend it. The organic functions of railroading and manufacturing are quite dissimilar.

will be the most efficient examples of manufacturing administration.

Considered as a whole, these organic functions exhibit the operations of manufacturing reduced to their simplest elements. They may be regarded as a map showing the shortest roads. While it is possible to go from one place to another by other roads, the shortest road must be selected if efficiency in speed of travel is desired. They have therefore a double application—they indicate the fundamental points of view to be considered in setting up a new organization, and they give material help in diagnosing the troubles of an existing organization.

The five organic functions are, as above stated, virtually water-tight compartments. Now, if we observe that a certain ship lists, it is of the first importance to know in which compartment the leak exists. If more than one leaks, it is desirable to know which leaks the most, and not to waste energy in repairing the one that leaks slightly, when another is admitting water freely. Reducing the leak in one compartment does not reduce the leaks in any other. We want to know with certainty the exact locality of the most serious leak.

In industrial matters this kind of question is frequently up for solution. Inefficiencies in business cannot be diagnosed as easily and quickly as leaks in a series of tanks, and it frequently happens, in the absence of a clear perception of the very different functions of administration herein described, that energy is wasted in repairing the most obvious defects, instead of the most dangerous defects.

The first thought of many people, when confronted with the problem of tuning up a failing business, is to ''speed up'' Operation, *i. e.,* to ''increase output''. Now it may easily happen that to increase output as a first step may just be the very worst thing that could be done. The dangerous leak may not be in that compartment at all. The extra strain thus put upon a badly adjusted Equipment, or a weak system of Control, may prove to be the last straw that breaks the whole affair down. Many firms have found their product more costly and their deliveries more unreliable, notwithstanding that the improvements made in their operation were both obvious and considerable.

The object, therefore, of analyzing manufacturing administration into its prime elements or functions is to establish rules for practical guidance on the bed-rock of fact. We commence by observing facts, and afterwards their relations. Now the basic facts of administration appear to be the five organic functions under discussion. It will be desirable to begin by delimiting these functions, and establishing their existence as primary facts, proceeding afterwards to examine the laws by which their mutual relations are controlled.

THE ORGANIC FUNCTION OF "DESIGN".

In considering the subject of manufacturing, the first question that arises is—"manufacturing what?" If we visualize "product" as the answer, it must be visualized in terms of shape, size, and material, at least. We cannot have a product that does not possess at least shape, size, and material. It may possess other properties also, such as color, surface-finish, strength, marking or pattern, chemical composition, and so forth. But whatever these properties may be, they exist by virtue of a previously imagined design.

Here, then, is one natural and perfectly definite organic function, the existence of which cannot be gainsaid. For everything in the way of product must have had a beginning at some time or other in an act of design. Every new variety of product must begin in someone's mind. It must be worked out in someone's mind. It requires a conscious aim on somebody's part. Whether the act of designing lies wholly in thinking out a new chemical formula or imagining and drawing a new shape and size of piece; or whether it requires this, and more, namely, the planning of "jigs" in a machine shop, or of "cards" in a textile mill; or whether, on the other hand, the new product cannot be physically realized until a new machine has been constructed, or an old one modified to produce it—it remains equally true in all these cases that a conscious act or series of acts, of design, pure and simple, must first have taken place.

The important thing to observe at this point is that this conscious mental effort is one of design, *and of nothing else.* By designing an object, we do not make it as a product, we do not set anything in motion to make it. Our act is wholly unassociated with any further *necessary* action. In fact many designs die at their birth, and none of the other functions come into play at all with regard to them. Design, therefore, must be recognized as an organic function entirely independent of all the others. It does, however, necessarily precede the functioning of any of the others. Unless we have designed something (or have taken someone else's design) we cannot operate, we cannot compare, we cannot control, we cannot run equipment, for we have as yet nothing to manufacture.

The function of Design, though always and necessarily present, has a very varying degree of development in different industries. In some it is merely rudimentary, in others it forms a considerable part of the total expense of manufacturing. In one kind of industry design is never undertaken without the certainty, or at any rate the intention, that it will presently be translated into product. In another kind of business the preparation of designs is a highly speculative undertaking, for the purpose of seeking orders which after all may go elsewhere. In one kind of industry designing is nearly all art. In another it is closely associated with science. In some cases design of the product itself ends the matter. In other cases, design of the product must be followed by design of tools and fixtures, or even by design of new machines before it can be realized. Yet in most of these diverse cases the points where the act of design begins and where it definitely ends remain clear and unmistakable.

Design is the *prescriptive* function. It prescribes in advance, shapes, sizes, properties. It sets up standards in regard to product. It specifies intentions. It is the original source of action and the final arbiter in determining what action shall be taken. All the other functions exist for the purpose, and only for the purpose, of carrying out the behests of Design. Consequently the importance of careful and correct design cannot be overestimated. As it is the source, so it may be the poisoned source of all the other activities, the originator of inefficiencies, the advance agent of disastrous loss. In proportion as the industry is a complex one, in proportion as the product is made up of accurately fitting components, or has to pass through finely adjusted processes in series, is the task of design more and more difficult and important.

All this will no doubt be admitted without discussion, because the idea is familiar to everyone concerned with manufacturing. But while the *commencement* of the process of design can be readily pictured—the first rough and vague ideas as they present themselves to the mind of the designer, the *final* limits of design are by no means as clear in some industries as in others. Where the matter is a very simple one, say the production of some flat stamped part of brass, it is generally assumed that the work of the designer is over when he has drawn it accurately to scale. It is then for the tool-maker to prepare his dies so that they cut out a facsimile of the design, and that is all there is to the complete process.

But if we consider Design as the prescriptive and originative function, its limits cannot be properly drawn at this point, even in so simple a case. The material, and the size and shape of the piece have been specified, and a standard thereby set up that Operation must strive to attain. We have prescribed dimensions as regards material, but we have not prescribed dimensions as regards time or labor. Yet modern practice is beginning to demand that the specification of labor in regular, recurrent jobs shall be carefully attended to. It will be desirable to discuss the reasons for regarding this work as a part of Design.

If instead of a simple flat piece of brass, it were required to make a component of rather twisted shape, with holes and grooves in it, and with a surface or surfaces that had to fit other parts with considerable exactness, then it is not too much to say that the design of this part should be carried out while keeping in view the method in which it is to be made. To design a piece that cannot be made is, of course, useless. To design one that can be made only with great difficulty, and with an unusual expenditure of labor, is undesirable. In proportion as the designer pictures to himself the operative processes—the specific acts of hand or machine operation—necessary to carry out each detail in the design as he settles it, so will the chances of economical manufacture be increased. But this implies that his ideas on the suitable way to make the piece should be recorded and incorporated along the drawing and thus made part of the design. In other words, we have here a further specification or prescription, beyond dimensions of material, namely prescription of the kind of operation.

We cannot stay to discuss here the conditions under which it is useful to study and specify in advance the time of operation (and compensation for labor which depends upon time) and the use of particular tools and machines. But *whenever* such work is desirable, it must be regarded as a completion of Design and nothing else. This rule does not arise from the necessities of classification, it is not a mere concession to nomenclature. It arises from the practical fact that design for use, *i. e.,* the physical shape, etc., of the piece, and design for manufacture, *i. e.,* the indication or prescription of the *method* of manufacture, are very intimately connected, and that neither of them is connected with anything but that one individual piece.

In those industries in which these matters are worked out in advance, we must regard the design as incomplete until *all* the specifications *that it is intended to make in advance* are equally completed. These specifications will then represent the full set of behests that Design has to make to Operation about that particular article. Whether or not the article is ever made does not matter, and this consideration forms the natural dividing line between what completes Design and every subsequent operation. Design provides a string of particulars, of specifications and standards, and hands them over to Operation to carry out. If Operation does not carry them out, one of three things will happen. Either (1) nothing at all is made, or (2) something is made which is physically different to what the design calls for, or (3) the correct physical standard has been reached by different methods, or by the use of different tools, from those specified.

The first case has little significance, because it obviously arises from some outside influence, such as cancellation of an order; the second case means usually that someone has blundered, and that rejection will follow; the third case will usually mean that either a better way has been discovered in the shop, or that exigencies of some sort, like breakdown of machinery, made it necessary to override the specification. But in each of these three cases, the design remains unaltered, and is available for future use until it is modified in some particular. In other words, all these preliminary specifications are acts of design and *nothing else.* They do not, of themselves, make product, they do not set anything in motion to make it,—they are wholly unassociated with any further *necessary* action. They can be used as a basis of operation, or put away on a shelf, with perfect indifference. They are self-contained designs, and cannot be regarded in any other light.

This insistence that Design includes every kind of specification pertaining to a certain product may seem unnecessary, but we shall see in subsequent chapters that it is of great practical importance. In some industries of course, Design is quite rudimentary—it may take the form of a simple recipe or chemical formula, but in no industry is it entirely absent.

We may now indicate the scope of Design, in a type of industry in which it is *at a maximum of development,* by means of a tabular statement as shown on pp. 51-52.

It will be observed that we have confined our attention entirely to that aspect of Design which has to do with pre-arrangements for manufacture. There is, of course, another side of Design which has to do with the technical efficiency of the product itself. The efficiency of Design for technical use and its efficiency for economical manufacture are entirely separate. We may, for example, design a new kind of machine to do some special class of work. When built, however, it may prove to be less useful than was antici-

TABLE I. SCOPE OF THE ORGANIC FUNCTION OF DESIGN AT ITS FULLEST DEVELOPMENT.

The piece or other unit of manufacture.	**Nature of Material.** May include specification of constitution of material, such as iron, steel, brass, yarns, or other particular materials, and alloys, or other particular kinds of mixtures; and of physical properties, such as hardness, elasticity, elongation, etc. **Shape and Dimensions.** May include specification of margins, allowances, fits, tolerances, and prescribe sizes of sheets or rolls from which the pieces are to be cut and "number out". **Other Properties.** Specification may include the prescription of surface-finish, patterns or markings, color or shade, etc. It may also be concerned with exact *quantities,* as in chemical manufacture.
The accessories peculiar to the manufacture of the piece.	**Template, Jigs, etc.** In addition to the design of the unit of product, it may be necessary to design special jigs, templates, or cards, and special machine fixtures. * **Tools.** In some industries it may be desirable to specify the exact tool, drill, broach, reamer, or tap by which the dimensions are to be realized or the special type of cutter or other standard accessory to be used on the jobs. This is chiefly for the purpose of securing accuracy and saving time in the operation department. **Special Rigging.** It is sometimes necessary to design temporary devices for handling unusually bulky, heavy, or awkward pieces. **Machines.** In some cases the new product may demand a novel kind of machine, or a reconstruction of an old one, which has then to be designed specially.

* See note on page 52.

The details of operation.*

* **The Method.** May include specification of the particular machines to be used, and their speeds and feeds, the sequence of operation, the sequence of handling at each operation, etc.

* **The Time.** May be specified as preparation time and operation time. Details may be carried very far, and time of every motion in extreme cases may be specified.

pated. But on the other hand, its reduction to components for manufacture and the design for manufacture of such components may have been extremely efficient, resulting in the machines being built at the lowest possible cost.

This suppositious case shows that technical design (or Design for Use) is a separate kind of aim from design for manufacture. Either of them may be highly efficient, while the other is inefficient. In this chapter we have considered design from the manufacturing standpoint alone. It is taken for granted that the product is worth making, and that it represents the highest efficiency

* These items of specification are necessary in proportion as the science and practice of operation is at a low level, or where, as in some machine shops, there is a great variety of work at each machine. In proportion as the scope of machines is limited, *i. e.*, where they can only do one thing at one speed, in one way, the necessity for this class of detail disappears. In some industries there is almost no room for it.

for Use. *The technical efficiency of Design is not a part of the science of Administration.* This view will be further developed when we come to consider the technical side of Operation.

Though a logical arrangement demands that Design should appear as the first, and Operation as the last, in our list of organic functions, since the former is the first step, and the latter the final aim, of all manufacturing activity, it will be more convenient, in this chapter, to consider operation immediately after Design. Historically speaking, Design at one end of the process of manufacture, and Operation at the other, are the oldest and most primitive organs of the business of making things. These two are, in fact, the functions of prime importance. In primitive stages of industry they occupy nearly the whole field, and the remaining organic functions are merely rudimentary.

Even today, if we give an order to a shoemaker-craftsman to make a pair of shoes, he first designs the shoes on the basis of the measurements he takes of our feet, and then proceeds to the operation of making them. He is his own Control; his need of Comparison is confined to seeing that he keeps to his measurements, and to the process of "trying-on"; his demand on Equipment is practically nil. Design and Operation are the only developed functions in craftsmanship. It seems desirable, therefore, to consider the two prime functions of manufacturing together in this preliminary description of their fields of action, leaving the complementary functions which have arisen out of the necessities of modern large-scale industry till later.

The place of Analysis in regard to Design will be referred to in the Chapter on Organization of the Function of Design.

THE ORGANIC FUNCTION OF OPERATION.

The aim of Operation is the transformation of material into new forms conformably with Design. It does this by applying labor to machinery in most cases, sometimes by labor alone. Whether we observe the drilling or planing of a piece in a machine shop, the eyeletting or sewing of a shoe "upper", the printing of a page of type matter, the embossing of a crest on a sheet of paper, the working of a carpet loom, the mixing of chemicals in a vat—the principle is the same in essence, namely:—*alteration of the status* *of materials in accordance with previously determined design.* But the two functions are always entirely distinct. Operation will not give rise to a new design. Design by itself will not transmute material into new forms. By no possibility can we confuse the end or aim of these two functions, or get them mixed. It is therefore reasonable to believe that they are truly *fundamental.*

In Table I, however, it will be seen that Design in some cases prescribes methods and times of Operation with great minuteness. This should not lead to confusion, since it is well within the scope of Design to "tell which way". It tells which way in regard to methods of operation only in those cases where Operation might have several alternative ways of doing the work, and it indicates what it considers to be the better way. But "telling which way" is not doing the work. It is the function of Operation to do the work. Even when the "way" is prescribed, it may still do it badly.

Operation comprises the actual technical processes of manufacture, the operation of the machine, the use of the tool, and the skill of the foreman and of the operative, as embodied in the way they apply the tools and machines to the material. Alteration in the status of material is the fundamental and distinguishing act of Operation.

Necessarily, industries differ in the function of Operation to a much greater extent than in any other. Every industry must have a fully organized function of Operation, and this will be the most highly individualized part of it. The technical processes involved in making carpets or in bleaching have no relation to those involved in making locomotives or furniture. The making of silk neckties demands wholly different kinds of skill and wholly different machinery to the making of steel rails. But in each of these industries the operative function will be clearly marked off. Whether we are dealing with wool, cotton, wood, silk or steel, it is the alteration of status in these respective materials that is the task of Operation.

Operation, then, is the function which makes, transmutes, or transforms. All the other functions are set up with a view to serve Operation. Design tells What and, in some cases, Which Way; Equipment provides suitable conditions for Operation, Control arranges matters so that Operation may be continuous and without hitch; Comparison observes and records how far Operation has complied with the intentions of Design. But the end of all, the main aim in manufacturing of every kind, is Operation.

The *technical* efficiency of operation is not part of the science of administration. The action of dyes, the strength of yarns, the properties of materials, the strength of castings, the wearing properties of silk ties, the durability of steel rails, are not in the province of an administration expert, but in that of a *technical* expert in one or other of the industries concerned. In other words the technical basis of operation is not a part of the science of management.

When an executive claims, as he frequently does, that "my industry is peculiar", he is wholly right as regards the function of Operation, and largely wrong as regards the science of management. In every industry, and even in most plants in the same industry, the department of Operation *is* peculiar and individual. But in every industry the functions and principles of administration are universally applicable, and a large number of their variations are common to a wide range of industries, to say nothing of plants. Now the science of management does not teach, and does not pretend to teach, operative efficiency. If we do not know how to temper steel springs, or how to prevent a fabric from shrinking, that is a defect in operative efficiency that no system of management can, by itself, overcome.

Given certain approved technical methods, we can, by aid of the science of management, do a great deal to study the effect of those methods in detail, to compare the efficiency of different methods, to establish a connection between amount of product and cost of labor; but we cannot discover technical secrets. Only technical observation and experiment can do that. The different scope of management and technology is thus indicated. The function of Operation is a function of administration. It permits us to apply the technical knowledge we possess in the most efficient way, but does not ensure that our knowledge is the best. This point should be clearly understood.

We may now exhibit in tabular form the principal fields of the organic function of Operation*. They are summarized in Table II, page 59.

* The place of Analysis in Operation will be referred to in the Chapter on "Organizing the Function of Operation".

TABLE II. SCOPE OF THE ORGANIC FUNCTION OF OPERATION.

The Units of Operation. Operation is the synthesis of a number of separate trades, skills, and processes. Usually, but not always, these are exercised through the operation of machines. In most modern industries machines occupy nearly the whole field, and such hand skill as remains is usually in the nature of producing greater refinement of finish than machines can be made to give. Every distinct skill or machine process is a unit of operation. Operation itself depends for its efficiency on the application of processes to units of product in accordance with the best technical practice.

Preparation for Operation. In some industries, whenever product is varied, it becomes necessary to modify, add to, or take away some accessory of the machine. This is termed Preparation and should always be reduced as much as possible, as it is a loss to production. It is generally considered to include, also, restoring the machine to normal condition and cleaning up after a job.

Operation. Operation is the actual technical work of cutting, pressing, twisting, heating, weaving, mixing, assembling, etc., as performed on the material in accordance with the specifications of design, and by aid of the best technical effort able to be put forth by the operator.

Note. Operation does not include anything but the application of technical skill to transform and transmute material. Therefore it does not include inspection, maintenance, or the handling of product at any other time than when putting it in position for operation and removing it from the machine.

Thus far we have dealt only with the two primal functions of administration, Design and Operation. These have been shown to occupy entirely independent fields. The act of design is in no sense an act of operation, hence it follows that throughout the whole organization these diverse functions must be carefully separated, or more correctly, not be allowed to become confused. The practical value of recognizing this distinction is already very great, notwithstanding that the other functions have not, so far, come into the story. In planning an organization we know what properly belongs to a department of design and what rightly belongs to the operative department. We know that Design *prescribes* and that Operation *carries out.* Consequently the allotment of duties should be made on these lines, not only at the top, but throughout.

But we know more than this. We have observed that Operation is the *technical* function, and this implies that it will have troubles peculiar to itself, which troubles will not be avoided by doctoring other functions. If, as said above, we do not know how to temper steel springs properly, improving Design, Control, Equipment, or Comparison will not give us the secret of success. Each function has certain types of inefficiency of its own, which must be resolved within that function, without help from outside. It is a matter of great practical importance to recognize precisely what these troubles are. Each function is a water-tight compartment.

Nevertheless, there are some *hindrances* to Operation that will be subject to amelioration by the correct action of other functions. Wastes will be recorded and disclosed. Delays and interruptions in the movement of materials will come to light. Irregularities in the supply of power, in the maintenance of critical temperatures, in the careless handling of product, will be regulated; but these are only hindrances, and their absence does not, in itself, heighten operative efficiency. *Why* a particular alloy is brittle, *why* a particular fabric will not take the desired "finish", *why* a particular leather cracks or splits,—these are questions of a technical nature that technical inquiry must settle for itself.

Yet, as will be seen in the succeeding chapters, the science of management does embrace the means and methods by which these technical problems can be attacked. It must suffice at this stage to note that the organic function of technical operation stands by itself, in such a way, and with the clear advantage, that its troubles and problems shall not be confused with those (already numerous enough) of the art and science of management proper.

Chapter IV

THE ORGANIC FUNCTIONS OF ADMINISTRATION (*Continued*)

IN the previous chapter we discussed the two primal organic functions of administration, namely:—Design and Operation. It will now be necessary to discuss what, historically speaking, may be considered the three secondary functions, viz:—Equipment, Control, and Comparison.

In the large plants of today, however, these three functions, so far from being subsidiary, assume great importance. It may be laid down as a law that in the progress of an industry, as soon as any new function is superadded to the primal functions of Design and Operation, it assumes equal rank with these latter. In the modern plant, therefore, it is not correct to say that Design or Operation are more important than Equipment, Control or Comparison, since these latter cannot be dispensed with, and cannot be permitted to fall into a condition of inefficiency without bringing as much trouble as would follow if one of the two first should become inefficient. It is this wonderful sensitiveness of the industrial organism in all departments that makes it so imperative to settle some definite principles in regard to administrative problems.

THE ORGANIC FUNCTION OF EQUIPMENT.

As soon as any industry enters the factory stage the question of Equipment will begin to assume importance. Equipment is that organic function that provides *conditions* for production, and these conditions are of varied character. Every considerable business must have, for example, suitable premises, and these premises must be lighted, heated, kept clean and bright, and the space they afford must be utilized economically. Secondly, power will be required, and this involves the provision of equipment of another kind, which also has to be maintained and kept going. Thirdly, the storage, handling and transport of material necessitates suitable equipment of still another kind, and this again requires to be maintained in a state of efficiency. Fourthly, there is the operative equipment itself which has to be repaired and kept in order.

Efficiency of Equipment naturally has two aspects, one of which may be called the installation, and the other the current or administrative aspect. In the installation division must be placed the selection and the arrangement of the Equipment, including the very important question of space-utilization, or lay-out, the suitability of each part of the site and buildings for the purpose to which it has been allotted, the question whether this or that method of generating and transmitting power should be adopted, the provision of proper storage bins, racks and fixtures, the mechanical means of handling material by cranes, travellers, conveyors, trucks, industrial railways and so forth, and the grouping of operative machines.

All these dispositions are termed installation questions because they are, properly speaking, antecedent to the administrative use and running of the Equipment. They represent engineering selection. Once the Equipment has been installed, then its current use is obviously an entirely different matter. The organic function of Equipment therefore is concerned first with the *installation,* and then with the *maintenance* of all the appliances used in the factory, and that is really its special field. But in some cases maintenance involves operation of the equipment itself as, for example, in the case of the power service, and such matters as the lighting, heating, ventilation and cleaning of buildings. On the other hand, the working of the productive machinery is the function of Operation, and the working of the storage, and conveying or material-transporting equipment is the function of Control.

Once the equipment has been installed, then the .administrative maintenance of proper physical conditions becomes the chief task of the organic function of Equipment. It must attend to the keeping of the buildings in good order, and clean and bright inside; to the question of fire protection; to the maintenance of pure air at the right temperature; to abundant light, and to providing power in the necessary quantity during the right periods. All this is obviously an administrative matter, viz.: the maintenance of *conditions,* of physical conditions necessary to the whole course of Production. Similarly the task of keeping all machinery and appliances in a condition of efficient repair is, with equal obviousness, also a maintenance of conditions necessary to the work of the various departments using such machinery and appliances.*

TABLE III. SCOPE OF THE ORGANIC FUNCTION OF EQUIPMENT.

Installation or Engineering Selection	**Buildings.** Allotment of different parts of buildings to suitable uses, *i. e.,* the lay-out of departments, installation of appliances for lighting, heating, ventilation, fire protection, etc.
	Power Plant. Selection of the right type of plant, and suitable means of distributing and delivering power where required. Consideration of the margin of power necessary.
	Materials. Provision of adequate equipment for storage and conveyance of materials. Storage racks, bins, fixtures, cranes, travellers, trucks, conveyors, etc., considered in reference to the volume of work and lines of travel.
	Machinery. Provision and installation of machinery and design of lay-out in relation to travel of product.
Maintenance or Administrative Use	**Buildings.** Repair and maintenance of structures, maintaining an adequate service of light, heat, ventilation, and fire organization. Keeping premises clean and bright.
	Power. Keeping up supply of power in right quantity, during right period, on an economic basis. Attending to storage of fuel against contingencies, oiling shafts, maintaining belts, and so forth.
	Machinery and Appliances. Repairing and maintaining all kinds of equipment in working order.

* The use of Analysis in regard to Equipment will be referred to in the Chapter on "Organizing the Function of Equipment".

Before leaving the subject of Equipment, it may be well to point out the independent scope of this function. It is evident, in the first place, that it has nothing to do with design of product. Neither has it anything to do with the efficiency of technical operation. Its business is to provide and maintain suitable *conditions* under which Operation may be free from certain hindrances, such as dark and stuffy shops, irregular supply of power, inadequate transporting appliances, and so forth. But its efficiency is quite a separate kind of efficiency from that of Operation. The conditions provided by Equipment may be perfect, and yet the Efficiency of Operation itself may be at a low ebb.

Nevertheless, in examining a plant for causes of inefficiency, we should begin by examining Design, and next Equipment, because Design originates everything in the way of product, and Equipment originates everything in the way of physical conditions. As has already been remarked, efficiency in one function does not increase efficiency in another, since each represents a totally different quality of efficiency, but on the other hand, any inefficiency anywhere is a hindrance to the total efficiency of the plant, and may *hold back* the possibilities of efficiency in any other function. But removing a hindrance does not increase other qualities of efficiency.

We may, for example, be able, under the most favorable *conditions,* to walk four miles an hour. Under given poor conditions, say a very bad road, our pace may be reduced to three. If the road is improved, we may reach three-and-a-half; if it is made perfect, we reach our maximum of four. But no improvement in the road will enable us to walk beyond our maximum pace of four. No such improvement will enable us to walk five. Yet perhaps competition might demand that we should be able to walk five, or go out of the race. In that case we must tune up our Operative function, viz., our powers of walking, for that alone is at fault.

When, therefore, it is said that the efficiency of all the functions is independent, this is what is meant. It is not implied that inefficiency in one function will not *hinder* another. Obviously, if one function reduced its efficiency to zero (that is, ceased to act altogether), all the other functions would stop. If there were no road, we could not walk at three, four, or any other number of miles an hour. Similarly, if designs are stupidly made so that process work requires extraordinary skill to produce the results specified, this will hinder Operation from producing economical work, however efficient it may be in its own domain. But the converse is never true. If Operation is careless and unskilful the best designs or the best equipment in the world will not improve these bad characteristics out of existence. It may make them less harmful in their consequences but they will still exist.

Each function has a special kind of efficiency in its own domain *which can be hindered but never helped* by the conditions of efficiency in any other function. It is the absolute truth of this law that gives the organic functions all the importance they may possess as practical guides.

THE ORGANIC FUNCTION OF CONTROL.

This function has also a field of action equally as definite as that of Design, or Operation, or Equipment. It has its definite *aim,* which is quite clear-cut and precise. It supplies, as it were, the human motive power of the business. It seeks to *move* things.

Control, like Equipment, has its installation as well as its administrative aspect. In the former sphere it fixes the relations of persons throughout the plant. In the latter sphere it selects the right personalities to fill the posts whose duties are thus fixed, and supervises their daily performance of these duties. Control is, in fact, the nervous system (or more correctly one-half of the nervous system, the other half being Comparison) of manufacturing administration. The analogy is indeed very close. It conveys orders from the central brain (the executive), it responds to stimuli from without, and it is more than a mere telegraph system of nerves, for it has well marked ganglia, or secondary nervous centres, forming local subordinate brains concerned with special duties (stores departments, pay departments, and so forth), and responding automatically to stimuli without the central brain being concerned.

It is evident therefore that the arrangement of the system of *devolution* which is the most marked characteristic of the function of Control must be very carefully planned. Since the executive cannot be in all places at once, it is necessary to provide subsidiary local brains or officers to whom definite special duties are allotted. Each of these subsidiary brains will have routine work, in the performance of which it has been coached and instructed, once for all, by the central brain, or executive. So long as the stimuli to which the local brains respond (or in other words the business they transact daily) are ordinary matters of routine, the executive remains unconscious of them. But as soon as a stimulus arrives not included in the routine (*i. e.,* when something unexpected happens), then the subordinate officer must know to what higher brain to turn for instruction.

Historically speaking, *all the organic functions represent successive devolutions of the function of administration.* This is clearly shown by Table IV (facing page 73). In the beginning, one man performs all the functions of manufacturing, as in the case of the shoemaker cited in Chapter V. Then he separates out the function of Operation and entrusts that to other hands. Next he puts someone in charge of his Equipment and so denudes himself of that function. Then, possibly, he engages a designer and ceases to perform that function himself. Finally he

TABLE IV. SUCCESSIVE DEVOLUTION OF THE ORGANIC FUNCTIONS OF MANUFACTURING DURING THE RISE OF AN INDUSTRY TOWARD MODERN CONDITIONS

Stage 1. Beginnings of Industry.— The craftsman exercises all the manufacturing functions in his own person. (Selling and finance are not included in this discussion.) "The day of small things."

Stage 2. Devolution of Operation.— A workman and apprentices are engaged for the manual or operative work. The workman exercises supervision and becomes in course of time a fully fledged foreman. Later he has to devolve some of his duties on other foremen, and is called superintendent. (Once an organic function is separated out, devolution goes on *within* it.) At this stage the owner looks after everything else, but ceases to do operative work.

Stage 3. Devolution of Equipment.— Equipment begins to assume importance. A mechanic is engaged to run the power plant, attend to repairs, and do odd mechanical jobs. Later we see him represented by a "works engineer" with a power staff, a repairs staff, an electrician, *etc.*, on whom these specific tasks have been devolved.

Stage 4. Devolution of Design.— The owner finds it necessary to devolve the preparation of designs and drawings, and so engages a designer and frees himself from this function. The designer's work grows and is devolved on subordinates until we may find ultimately a chief engineer, chief draftsman, a production engineer, an experimental staff, *etc.*

Stage 5. Devolution of Comparison.—Up to this point the owner has only guessed at costs, from rough memoranda compiled by himself. He now devolves this work on a cost clerk, who represents the accounting side of Comparison. As the business develops the cost clerk has to devolve details on others, and becomes an accountant, with subordinate pay clerks, time clerks, stores-record clerks, *etc.* Also the owner ceases to "pass" on each piece of completed work, and devolves this task on an inspector, who represents the technical side of Comparison. Later the inspector's work expands until we find a fully developed testing and inspecting department.

NOTE.—At this stage all the activities of administration, exercised by the owner of the business at the beginning, have been devoluted to Organic Functions (themselves made up of groups of individuals with specific duties), *save and except his personal controlling and supervising work*—or, in popular language, his function as "boss." This latter work, however, soon outgrows the possibility of his attending personally to all of it; hence we arrive at:

Stage 6. Internal Devolution of Control.—Control, which remains vested in the owner of the business, is exercised by means of a regular internal devolution of this function. It begins with the owner himself, who is directly supervising the heads or executives who have been placed in charge of the functions already separated out (as above), and also goes down through the purchasing agent, store keeper, order department, correspondence office, tracing department, shipping office, and so forth in definite lines of devolution for special duties Later we find the organization of "staff" assistants and advisers, whose expert knowledge is at the service of those requiring it.

NOTE.—The five Organic Functions are now completely separated and organized and each has its own internal system of devolution, enabling it to fulfill its special purpose. Our discussion of the problem of management as presented in this book ends here. The organization for *manufacturing* is now complete. But in large businesses the owner (or the Board of Directors representing the ownership) withdraws still further from actual contact with routine. We then reach:

Stage 7. Final Stage.— The Administrative and the Determinative elements of Management are separated. The former is devolved on a president or general manager, who is personally responsible for the correct working of the five functions of administration. The Determinative element is reserved by the directors as their special field. They decide on points of policy. But as these decisions are usually based on financial considerations that have little or nothing to do with manufacturing proper, this final stage is not considered in this book.

engages an accountant and an inspector and hands over to them the function of Comparison. But he still has left the function of Control, which he continues to exercise.

As the business grows, however, devolution *within* all the functions becomes necessary. The designer must have his assistants. The accountant and the inspector must have subordinates for specific duties. The superintendent must have foremen and assistant foremen. The engineer must have men for the power plant and other men for the repair staff. And the executive himself, exercising the function of Control, will soon find himself in need of devolution also. He cannot be in several places at once. He cannot receive customers' orders, and circulate them to those concerned; he cannot purchase material, nor receive and take care of it; and at the same time exercise the higher function of Control, namely:—seeing that everyone is doing his duty to the best of his ability.

Consequently he devolutes the subdivisions of Control, as before he devoluted the big organic functions. In this process of throwing off or devoluting work, there comes a time when what is devoluted is no longer worthy of being regarded as a separate organic function, and so while some case might be made out for considering the purchase, care, and handling of material as so entirely independent a kind of aim or activity that it becomes organic, still it is so intimately connected with the prime factor of Control, namely ordering, that it is best included in that function.

This imaginary case of the development of a plant from small beginnings will serve to make plain what Control really is. It is not Design, it is not Operation, it is not Equipment, it is not Comparison, for we have seen all these organic functions thrown off one by one by our suppositious manufacturer as his business is increased. *It is that function which co-ordinates all the other functions* and. in addition, *supervises* their work.

In popular language it is the function of the "boss". As Design is the originator of the nature of product, and Equipment is the originator of conditions of production, so Control originates *orders.* It controls first by arranging devolution of duties (these being the installation of control and its arrangements are, of course, static and fixed) and secondly by issuing orders. It sets things in motion and keeps them in motion.

Control is the organ by means of which the picture of management that exists in the mind of the executive is realized as an actual fact. No system is ever more than this. No system can be greater than the executive that wields it to effect his purposes. In our admiration for clever arrangements of system, of forms, books, schedules, planning boards, and records, this simple and elementary fact has become obscured, but it remains today as true as ever. Incompetent generalship has, time after time in history, brought the most disciplined armies to grief. Competent leaders have also, time after time, built up victory out of unpromising materials. The object of studying management principles is not to supersede leadership, but to discover the most efficient system of devolution of functions for the competent leader to use.

The advantage of sound theory to the competent leader is nevertheless great. It saves his energy. He can dispose his forces with less thought and with greater assurance than if he had to work out every detail for himself. If he is a soldier he can arrange the duties of his staff, his regimental commanders, his subaltern officers, his auxiliary corps of supply, transport and sanitation, with confidence, and is thus set free to devote his attention more easily to the prime business of *conducting* war. He is sure of his subordinate ganglia or local brains and of the way in which they will respond to the stimuli of their daily routine, and that is the first condition of success for all leaders.

In manufacturing, as in all great aggregations of human effort, the most difficult part of administration lies in first mapping out the sphere of duties of individual men, and then in selecting men of the right temperament and qualifications to fill these posts. In small businesses, we must sometimes fit the duties to the men who happen to be at hand, but this is one of the reasons why the very small business finds it difficult to compete with larger concerns, where devolution is on an extensive scale, and corresponds with the natural division of the organic functions. Control, as an organ of administration, comprises the specification of duties, the determination as to who shall issue orders, and what fields these orders shall cover; who shall transmit orders; who shall receive and interpret orders; who shall carry orders out. It comprises also the organization of experience and advice; who shall be the final authority on purchases, and who on tests. It comprises the careful planning of subordination, and mechanism for adjusting disputes between persons of equal authority in their respective spheres. *It is the organ concerned with duties, responsibilities, and the exercise and limitation of initiative.* It is the great Organ of Synthesis.

TABLE V. SCOPE OF THE ORGANIC FUNCTION OF CONTROL

Installation of Control

The Delimitation of Duties

Within the Other Organic Functions. Commencing with the heads of departments, *i. e.,* the men who are in charge of the organic functions of Design, Operation, Equipment and Comparison, it plans their duties, decides what subordinates they should have, and what specific duties these subordinates should fulfill. It therefore plans the interior structure of the systems by which these functions are exercised.

In Its Own Special Department. It plans the relations *between* the above departments, and says which persons shall confer, and when. It arranges all the specially administrative duties, such as ordering, receiving or storing material; receiving customers' orders and passing them to the various departments concerned; supervising the current work of all departments, in the light of costs, wastes, delays, poor work, and other irregularities. It arranges all this by planning specific duties for specific persons, including the organization of specialists' advice or "staff" assistance.

Administrative Function of Control
Supervising, Ordering, Instructing and Training

Within the Other Organic Functions. Once organized under a head, each function is to a great extent autonomous. In other words, control of the Departments of Design, Operation, Equipment and Comparison is exercised *through* the heads of these departments, who are responsible for seeing that their subordinates are carrying out their duties as planned originally.

In Its Own Special Department. Administratively speaking, control is the great co-ordinative function. It sets everything in motion by issuing orders. Its particular task is to issue orders in such a way that, when all have been carried out, the result is exactly what was intended. It also observes failures, studies their reasons, and sets in motion the mechanism of instruction or training to prevent similar failures in the future.

It will be recognized that Control is the great organ for *conducting* manufacturing. Design determines forms, shapes, materials, qualities, and the special tools, if any, by which these desiderata are attained. Equipment provides the best known physical conditions for both personnel and material. Control determines the acts of the personnel; it has to do with the stimuli that set people in motion; it deals with the influence of one person on another; it communicates, orders, explains, and teaches.*

THE ORGANIC FUNCTION OF COMPARISON.

Lastly we have Comparison. This is the last of the organic functions to be devoluted, as industry develops. It is, in an organic sense, of very recent growth. Every kind of plant where a number of men are employed must have some kind of Control (usually the simple devolution of authority downwards), but it need not have anything worthy of the nature of Comparison, save in so far as the check-book of its owner and his pile of unpaid bills represent that organic function. In fact, in the days of big profits the old-time manufacturer did actually compare the results of his undertakings month by month in just that simple way. In other words, in former days the organ of Comparison was rudimentary and quite undeveloped.

The *aim* of comparison is of an entirely

* The use of analysis in Control will be referred to in the chapter on Organizing the Function of Control.

different nature to that sought to be realized by the other functions. It is the organ by which we systematically accumulate Experience. It is therefore the function *which makes use of existing Standards,* and also compiles the data that enable us to revise these Standards from time to time.

The great instrument of Comparison is Measurement. One of the principal differences between the older practice of Management and the newer is, as Professor Dexter Kimball* has pointed out, the substitution of quantitative for qualitative methods wherever possible. Instead of ordering coal and pronouncing judgment on its quality after it has been burned, we specify calorific values and ascertain that they are present before accepting the consignment. Instead of putting materials into the cupola and expecting them to come out right, we make sure that they do come out right by analyzing the product and ascertaining that the correct proportions exist in it. We keep stores and materials under lock and key and weigh and measure out what is wanted for specific jobs. We analyze the elements of jobs, and find out how much labor should properly go into them

* Principles of Industrial Organization, p. 249.

before we contract with the operator to do the work.

All these proceedings involve Measurement, but measurement by itself is of little value, unless we have something with which to compare the quantity or value so measured. To measure without comparing is an idle task; it would be like the boys' amusement of writing down the numbers of automobiles as they pass him on the highway. Measurement, in short, is but the tool or instrument of Comparison.

But before we can compare anything we measure with another measurement, we must have the latter in our possession. In other words we must already be in possession of a STANDARD. The Organic Function of Comparison, therefore, is that which concerns itself with the setting up and comparison of standards. Such standards may not arise out of the experience gathered within the plant. They may be standards gathered from the experience of others in the first instance. Thus we may have a standard of power cost, of calorific fuel value, of water evaporation per pound of fuel,—these are general standards, common to all work of the kind. Then there is a class of arbitrary standards, such as a 54-hours week and a consequent comparison of how far employes comply with such standard, or how far machines are operating all the time or less than the time. Then there are standards special to the plant, such as time allowances on jobs, quantities of materials allowed to be held in stores, weights of castings, formulae for mixtures, output of specific machines, etc.

Writing some fourteen years ago in The Engineering Magazine, the present author said, "The object of the organization . . . should be to collect knowledge of what is going forward, not merely qualitatively but quantitatively; it should provide the means of regulating as well as the means of recording." This was at the time when cost accounting was being developed, and the idea of standards had hardly received discussion, but since that date the quantitative idea has steadily grown, and is now recognized as the proper basis for all industrial operations.

Comparison, it has already been stated above, is to be likened to the receptive half of the nervous system of the body. It has its sub-organs of sense, its clocks, time recorders, weighing machines, scales, counting machines, chemical and mechanical apparatus for testing, just as the nervous system has the five senses of sight, feeling, taste, hearing, and smell. Its office, then, is first to measure, then to record, and finally to compare. In practice, it is the counterpart of Control, since its function is to report the results of orders and instructions, and, by comparison with standards, ascertain whether these orders have successfully attained their end.

Comparison has two well-marked spheres of activity: the one dealing with the properties of materials, either in their raw state, or after they have been subject to Operation; and the other concerned with Time, Quantity, Number and Value. The former of these we term the technical sphere of Comparison, and the latter the accounting sphere. The technical side deals with chemical and physical standards. It analyzes the composition of material, such as fuel, alloys, chemicals, steels, etc., which have been purchased, and determines if they conform with standards. It also, in some cases, analyzes the results of Operation, and examines the composition of Product to see if it accords with the standards set up by Design. Further it applies physical examination or "Inspection" both to purchased material and to product, and performs physical tests, as for hardness, elasticity, and so forth, when necessary. In all cases the results thus observed are compared with some expected result, or, in other words, with a Standard.

The accounting side of Comparison is concerned with figures rather than with properties. It does not investigate, it only records, groups, and compares figures. But here, again, it looks for agreement with certain expected figures, or in other words with standards. While the great field of accounting is the record and comparison of values, still it has other fields also. Certain efficiencies are measured in time, such as the attendance of employes, the utilized and idle time of machines, periods of maturing or seasoning in certain industries; and many more are correlated with time, such as the power demand, variations of pressure or vacuum, of heat, etc. Other efficiencies are measured by number or weight, such as the conformity to standards set by the firm for maxima and minima of stores and stocks, weight of fuel consumed per quantity of water evaporated, weights of the different components of mixtures, in accordance with specifications of Design, and so forth.

Lastly Comparison is applied to values expressed in money. This is commonly known as Cost Accounting, but actually the accounting and the technical spheres of Comparison form a single function, and should be parts of a single whole—the aim of which is to standardize whatever can be economically standardized and to observe, record and compare all instances of non-conformity with such standards. If this is not recognized, then duplication of work and inaccuracy of record are sure to result. Instances need not be given of what is included in the field of cost accounting, save to recall that the main object should be Comparison of actual with expected result, or in other words with Standards.

In all these fields there will be instances constantly recurring of want of conformity to standard—that is, of inefficiencies or wastes. The observation, record and comparison of wastes is one of the most important services that can be rendered by this function. Even customary wastes can be standardized, and these standards either approached or exceeded. In a properly organized function of Comparison, all the avenues of waste, whether expressible in chemical or physical want of conformity with Standard, or in time, quantity, number or value, are systematically explored, so that nothing escapes attention.

Comparison may be with existing records or standards or it may be for the purpose of future comparison with further records to be made at some future day, but no record is of value unless we are either able, or expect to be able, to compare it with something similar. Even the compilation of a pay-roll, which does not seem to have any ulterior object save as a list of liabilities, is really a record of Comparison, being the firm's account of what the man has earned, as compared with his own notion of what is due to him. And every practical paymaster knows that, on pay-day, these two records do not always tally.

In examining an ailing business, the efficiency of the organ of Comparison is frequently found to be low. In fact, measurement is frequently confused with Comparison. Elaborate records are prepared, complicated cost systems installed, but the only thing that these should exist for, namely, Comparison, is neglected. In this common fact lies a demonstration of the importance of basing all action on adequate theory. If, in installing a system of costs and records, the first question asked was, "With what Standard are these results to be compared?", it would often profoundly modify the form of the records and their complexity. For results can be compared broadly and in masses, and very important lessons deduced therefrom.

The value of detail only comes into play *when we are able and willing to compare detailed results with detailed causes,* and this demands a very high development of the function of control. If this development does not exist, then the detailed record is wasted.

It need hardly be pointed out that the aim of Comparison is entirely different to the aims of the other four functions. It occupies itself with quite different concerns from these.

Design makes use of the records provided by Comparison; so does Control; and Operation is frequently brought to book by their aid. But Comparison does not design anything, does not control anything, and does not make anything; it is an organic function entirely separate and distinct.*

FINAL REMARKS ON ORGANIC FUNCTIONS.

We have now passed in review, briefly and generally, all the five organic functions into which manufacturing administration is naturally divisible. We have seen that, in the progress of industry, these functions become separated out, or devolved, one by one as the business expands. We have also seen that the last thing that remains, after all the others have been separated out and set on their own feet, is the function of control.

The five functions, though entirely distinct, and representing wholly different kinds of aim, and therefore different qualities in which efficiency is to be attained, are nevertheless associated in different degree. Equipment is the base. In a modern plant, it is the first thing required. It embraces the very conditions of production, and therefore stands apart. Design and Operation, on the other hand, may be considered a pair. They have always been in existence and have always been closely associated since the first

* The use of analysis in Comparison will be referred to in the chapter on "Organizing the Function of Comparison".

cave man worked out the idea of an axe, and then proceeded to make it. Control and Comparison are also a pair. Together they form the brain and nervous system of a plant. Comparison is the receptive half, it observes, records, compares and transmits its observations to Control. Control is the central brain which receives information from Comparison, and from outside stimuli, such as customers' orders and directors' orders, and transforms its impressions into an act of will. It issues orders on its own account and transmits them to its subordinate local brains or ganglia, and so sets things going.

These analogies are not introduced for a merely fanciful purpose. They serve to picture the uses of the various functions. As has been remarked before, the division into organic functions is not fanciful or arbitrary either. It represents *the division of human faculty in manufacturing,* and it is believed by the author that the divisions here set down are truly fundamental and natural divisions. But, if this be true, it implies that organization to be successful must coincide, consciously or unconsciously, with just these natural lines of demarcation, and that where these natural divisions are departed from, confusion and uncertainty in organization must result, in proportion as they *are* departed from.

We shall consider the concrete and practical organization of the organic functions later, but first must come the consideration of certain regulative principles, by which this organization must be guided in every instance. These will be dealt with in the next chapter. The scope of the organic function of Comparison may be thus tabulated and summarized:

TABLE VI. SCOPE OF THE ORGANIC FUNCTION OF COMPARISON.

Technical Sphere of Comparison	**Chemical Analysis.** Compares the composition of materials with purchase specifications (which are, of course, based on Standards) and with the Standards specified by Design as to use of formulae of mixture. Embraces all Comparison other than physical, *i. e.,* all in which the constituent elements of bodies need to be compared with Standards.
	Physical Analysis, or Inspection. Compares the physical condition of materials which have been purchased or made, with the Standards specified by Purchase or Design, such as regards dimensions, color, pattern, surface finish, etc. Carries out physical tests for hardness, elasticity, elongation, tensile strength, *etc.* Passes on all physical properties not necessitating analysis.

ACCOUNTING SPHERE OF COMPARISON

Time. Records results of work of which the efficiency is measured in Time, and compares with Standards. Thus, attendance of employes, working and idle time of machines, time of operations in which result is dependent on duration, as in some industries, where product is matured, seasoned, *etc.*

Quantity and Number. Records fluctuations which are expressed in quantity or number, such as quantity of material in stock, consumption of tons of fuel in proportion to pounds of steam raised, number of employes present and absent, weight of components passing into a mixture, *etc.*, and compares these figures with Standards.

Value. This is the sphere of Cost Accounting. Records the cost of labor, expense, and material, as and when incurred and used, and compares with Standards. Classifies the results of work as utilized capacity and waste. Groups Labor, Expense and Material so that the Cost of jobs is ascertained and compared with expected or standard cost of such jobs.

The Organic Function of Comparison is concerned with observing and recording the operations of all the other Functions, and comparing the results with standards. It is the organ which systematically accumulates Experience and records it in such a form as to be available for application. Its broad divisions are Technical and Accounting, the one dealing with properties of materials, the other with quantities, numbers and values.

Chapter V

THE REGULATIVE PRINCIPLES OF ADMINISTRATION, OR LAWS OF EFFORT

WE saw in the last two chapters that the five organic functions of administration are really the expression of five entirely different kinds of *aim,* two of these being in a sense primal, viz.—the desire to Design and the desire to Make; and three are in a sense auxiliary, viz.—the desire to provide suitable conditions by Equipment, the desire to Control, and the desire to Compare what has been done with what we set out to do. Yet we have also seen that, in the large modern plant, no one of these functions is now of less importance than another. The primal functions of Design and Operation cannot be worked on the large scale without highly developed Equipment, Comparison and Control.

Another way of describing the nature of the Organic Functions is to say that they represent varieties of Effort—Effort applied in five different ways to produce five different kinds of result. As this is an important definition for our present purpose, it may be desirable to explain just what is meant by effort in this connection.

Effort may be mental or physical, but all effort which has visible results is a mixture of both. Mental effort must always have some kind of physical outcome, or it remains an unexpressed desire. To write a letter, or compose a speech, is a mental effort pure and simple, but it remains latent in the author's mind, until he translates it into physical effort of some kind, either by writing it down, or by dictating it to a stenographer, or by addressing an audience. Only thus can the mental effort be expressed and made to impinge on the consciousness of others and influence them to action.

It is not necessary therefore to divide Effort into mental and physical for practical purposes, since every mental effort requires physical means to express it, and every physical act on the other hand must have been prompted by a thought. It will be sufficient for our purpose to define Effort as any kind of human activity undertaken with a definite end in view. We have no need of any psychological subtleties in the matter; we may picture Effort very concisely as—*"Man trying to do something"*.

The importance of this definition to our present discussion will be realized when we remember that our Organic Functions represent five different kinds of aim. It follows therefore that these functions in actual work represent "Man trying to do five different kinds of things"; or, more correctly—five groups of men, each group trying to do a different thing. Reverting to the use of the word Effort in this connection we can say that, in manufacturing, there are five different kinds of Effort involved, each kind being represented by a separate organic function.

We have therefore an industrial body—the manufacturing plant—with certain organic functions clearly marked, and each of these functions is a structure ready equipped to do some one special thing, by the aid of human effort. The next question arises whether this application of Effort is haphazard, or whether it is regulated by law. An analogy drawn from the human body may first be considered before we examine this question at length.

The human body has not only organs and a nervous system; it has also controlling principles of action. In order that the normal functions shall go on, man must eat, drink, breathe and sleep. Similarly, with our industrial body, it is not enough to have organs like Design, Equipment, Control, Comparison, and Operation, we must also exhibit these organs in action, alimented by the living stimulus of Effort.

Just as man must be careful about the food he eats and the air he breathes, so we must be careful about the exercise of Effort. The efficient exercise of Effort does not come by nature or at any rate does not come wholly by nature. It requires training. Just as man cannot distinguish a poisonous fish from an edible one until he eats it, so most of our progress in industry, as in other things, has been made by the process of trial and error. The advances which have been made, and of which we hold secure possession today, are but a small fraction of the failures and tragedies that have been long since forgotten. Innumerable inventions are constantly being made, not one per cent of which come to practical fruition. In fact, were it not for one thing, mankind could never have progressed at all, so many are the pitfalls and so difficult the path of success in every department of human endeavor. Without this one thing he would be as the animal, confined in a round of instinctive habit, only to be modified in slight degree after ages of evolution.

The one thing that has saved man from this fate, this almost perpetual stagnation, is his faculty for accumulating and using the fruits of experience—and experience is but the record mentally assimilated of the efforts of ourselves or others in the past. It is by this faculty alone that progress is firm and assured. Thousands of years ago some cave man discovered that to bind a stone onto a stick gave him greater power to strike a blow, and mankind spread the record of this experience, and never lost the secret. We make hammers and axes in much the same way still.

The first and most important regulative principle of manufacturing, as of all other activity, is that

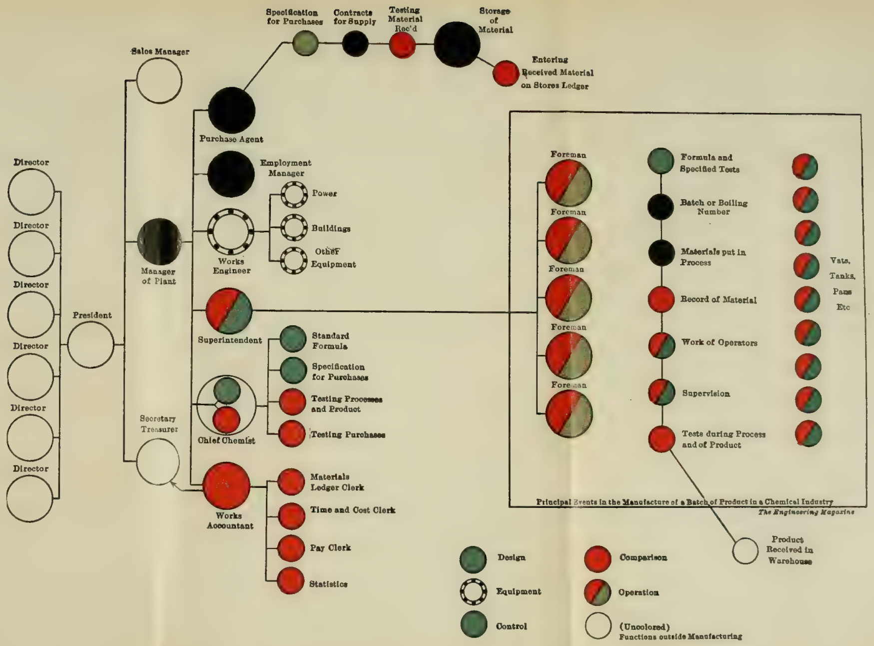
(1) Experience must be systematically accumulated, standardized and applied

Experience is the knowledge of past attainment. It includes a knowledge of *what* has been done, and also *how* it has been done. It is inseparably associated with *standards*

DIAGRAM II.—SHOWING THE DISTRIBUTION OF THE WORK OF THE ORGANIC FUNCTIONS IN A SIMPLE, CONTINUOUS, CHEMICAL INDUSTRY.

For comparison with Diagram I showing the Organic Functional development in a complex type of industry.

Note the rudimentary development of the Function of Design, which nevertheless exists and is quite indispensable to the organization. Also the much less developed Control (within the square representing the shops). Once set going, the processes follow on one another without the necessity or even the opportunity for continual guidance from the Function of Control. What is known as "planning" is therefore almost entirely absent in this type of industry.



of performance—that is, with the ideas of quantity and quality in relation to any particular method of doing something.

In practical matters, of course, this principle has a twofold application. It applies first to the building up and creation of the organic functions, and secondly to the daily routine of conducting business by means of those functions. In the former case we commonly apply experience gathered from outside, that of other manufacturers, of engineers, of accountants, of experts of various kinds—that is, we assemble existing standards—and we co-ordinate and perhaps supplement the experience thus available with that personally acquired by ourselves. The point is, briefly, that at the very beginning of our industrial life, we make use of, and in fact start from, the accumulated experience of the past as regards our particular industry.

Having started the plant, we proceed, or should proceed, to accumulate and to apply experience gathered on the ground. This experience may not modify our practice, either because we have discovered nothing new, or because we have neglected to observe that the principle calls for application as well as for accumulation. Further, if we are wise, we keep our attention on what others are doing. We hear or read of their new experiences, collate them with our own knowledge, and possibly extend them further. That is, we revise our standards from time to time. But if we do not do this, if we neglect to accumulate experience beyond the original stock with which we commenced business, and put it to use, then it is very certain that we shall stagnate, and very probable that we shall come to grief.

The principle that experience must be systematically accumulated and applied means first that we must observe existing standards, and secondly that we must constantly seek to improve them. It is the principle of systematic observation, of assimilation of knowledge, of study of causes and results. To a large extent it is the motive force behind all progress. *Standards are the milestones which mark this progress,* and as was explained in the last chapter, the organic function of Comparison is that in which experience is gathered and compared with standards. Hence it is the function over the doors of which the motto "Experience must be systematically accumulated and applied" should be always in evidence as a guide to action.

When we speak of the *use* of accumulated experience we mean its translation into effort of some kind. Otherwise experience remains a merely mental abstraction, without any practical influence. If we know that a certain fish with blue fins is poisonous, this (though a useful piece of knowledge under certain circumstances) remains practically inoperative until such a fish actually is offered to us. We have then to go a step further and apply the experience, and we can only do this by an action of the will dictating a movement to the bodily organs, or in other words by an effort. We either disregard experience, stretch out our hands and take the fish, or we allow experience to dominate our effort and we push it away.

This brings us to the second regulative principle of administrative action, namely:

(2) Effort Must Be Economically Regulated

In industrial matters the regulation of Effort is not by any means so simple an affair as the acceptance or rejection above cited. Industrial Effort is very complex, and tends to become more so. It is necessary for us, therefore, to analyze further the regulation of Effort as we find it in practical affairs, especially remembering that we are here dealing not with the effort of a single man, who can do only one thing at a time, but with the combined and simultaneous efforts of a collection of men all working to a common end.

It will readily be seen that this question of regulation of Effort becomes no mere academic discussion under these circumstances, but a matter of great practical importance.

Under modern industrial conditions the regulation of Effort is a matter of such complexity that its laws must be closely studied, and the methods of regulation analyzed. The first sub-section that naturally presents itself is that of Division of Effort. Contemplating a modern factory, the first thing that strikes us is that each one of perhaps hundreds or thousands of men is engaged on a different kind of work. Without this variety of occupations industry would be impossible. To make a typewriter would probable occupy the most skilful mechanic the better part of a life-time, if he had nothing to copy from, and no modern tools to assist him. The first sub-principle of the law that Effort must be regulated, is then, that

(2a) Effort Must Be Divided

It is comparatively easy to divide Effort—to assign definite pieces of work, or definite duties to this man or that, whether these pieces of work and these duties are mental or physical or mixtures of both. But only very simple and obvious tasks could be carried to a successful conclusion if that were all we did. The moment we divide Effort we divide responsibility. More than that, we divide control. If one man is making two parts to fit one another he is all the time looking ahead to the moment when he will have to bring them together as a single piece of work. But if the two pieces are made by different men, this control vanishes. The two pieces will only fit if we supplement Division of Effort by another sub-principle, namely, Co-ordination of Effort.

Whenever, therefore, we divide Effort, we must keep in mind this second sub-principle:

(2b) Effort Must Be Co-ordinated.

Co-ordination is the converse, or it might almost be said the antidote or remedy for

Division. For division of Effort is, after all, a necessity forced upon us, rather than a principle specially admirable in itself. There are, in fact, some kinds of Effort that it is impossible to divide, and the higher the faculties concerned, the more difficult it is to divide effort satisfactorily. In the authorship of a book, for example, the possibility of satisfactory division of effort is very small. Collaboration between two men for such a purpose is exceedingly rare, and the result is still more rarely of the first class. Few great books have had more than a single brain concerned in their production.

In industry, however, division of labor is a necessity, and as we have seen, this division is applied to Effort of all kinds in the modern plant. It is necessary therefore to give due prominence to the corrective principle, that of Co-ordination, if the end which we set out to attain is to be realized exactly.

The sub-principle Co-ordination of Effort might be described tersely as the doctrine of "gap and overlap". We have to make certain that our division of Effort does really cover the whole field, and secondly that Effort is not duplicated unnecessarily. In practice, the existence of "gap and overlap" may frequently be found, and the form they take will be discussed later.

It is not sufficient to divide a piece of work among several men, and to provide means (by drawings, working plans, or detailed instructions, or by the nature of the machines employed) whereby co-ordination of the separate efforts is secured. We must also seek a certain standard of efficiency in these operations. One of the great differences between the newer ideas of what proper management consists in and the older ideas, lies in recognizing that a further step is necessary. We must see that the work is carried out by the most direct path, that the methods employed by the various persons are the most advantageous methods known to us, that they are supplied with all the appliances and auxiliary aids to good and swift work that experience has developed up to now and that everyone is kept fully employed. In other words, a further sub-principle of the law that Effort must be regulated is brought into operation, namely, the Conservation (or Saving) of Effort. This may in some cases act as a limit to the division of Effort, because division may be carried so far that it becomes economically wasteful.

It is not sufficient to do the things required so that the end sought is attained, for it may be attained at too great a cost. It is therefore necessary to keep a sharp lookout on the various stages of the work in the light of the sub-principle that

(2c) Effort Must Be Conserved (or Saved)

We have now arrived at the stage where our regulation of Effort is nearly complete. We have distributed our work amongst a number of persons; we have taken precautions that the work of each will dovetail accurately when the various tasks are completed; and we have observed that each man has the necessary skill, the proper tools, and the requisite auxiliary aids to perform his task in the most efficient manner and the shortest time. It only remains that some recognition of his skilled assistance be made, or in other words, that he be paid for his labor. This brings us to the final sub-principle of the Regulation of Effort, viz.—that

(2d) Effort Must Be Remunerated

The relation of this sub-principle to the organic functions is one that must not be misunderstood. It has not to do with the nature of the incentive to be applied, because that is obviously a part of the third principle, presently to be discussed, viz., "the promotion of personal effectiveness". It does not embrace the application of bonus or premium systems. Its particular field is the study, in each organic function, *of what particular type of Effort* should be selected for encouragement and reward. It will be obvious, for example, that incentive as applied to the men in the shop, might be wholly unsuitable for the draftsmen, or the clerks, for the reason that their particular type of activity would not respond to the same kind of incentive. The remuneration of Effort, therefore, is that principle which leads us to the analysis of the different kinds of aims met with in the different organic functions, and enables us to determine *how and where to apply incentive,* so as to promote the efficiency of the particular function.

We have now recognized two great regulative principles, (1) that experience must be accumulated and applied, and (2) that Effort must be regulated in four ways, namely, by dividing, co-ordinating, conserving and remunerating it.

These two principles, it will be obvious, are closely related, since the way in which we regulate Effort depends upon the degree of our Experience, and the extent to which we practically utilize such experience. But as both Experience and Effort are human attributes (for we cannot speak of the experience of a machine or of its making an effort) there would seem to be indicated a third principle, qualifying in some way our attitude towards the human factor in production, and bringing the latter into sharper focus. Such a principle would obviously deal in some way with the one thing interesting to us in an industrial sense, namely, the perfectibility of the human factor for our purposes.

Such a principle can be formulated, and can be expressed in the following terms, viz.:

(3) Personal Effectiveness Must Be Promoted

This is, of course, equivalent to saying that the quality and quantity of effort put forth by the individual are controllable; that they depend upon conditions; and that these conditions can be studied and adjusted so as to extract the best results. This principle embraces among other things the study of *incentive.* In each organic function the application of the principle of the Remuneration of Effort will have shown what particular directions of Effort should be encouraged. It then becomes the task of this third principle to effect that encouragement. But this is really a much wider matter than a mere question of incentives, or systems of payment. The modern science of management recognizes that the human factor is one of the most subtle of the problems with which manufacturers have to deal, and that methods of incentive to labor are only one part of it.

Personal Effectiveness has, in the first place, a physical basis. The human organism cannot work effectively save between certain limits of heat and cold. It is affected by humidity, purity of atmosphere, quality of light, presence or absence of noise, and the necessity of eating and drinking at certain intervals. It cannot work, as a machine can, for indefinite periods. On the contrary periodic rest is essential to it, and this rest has an important relation to the quality and quantity of work performed.

It has also a psychological basis. Men differ from each other in temperament, memory, forcefulness or will, persistence, conscientiousness and a hundred other things. Some are fitted to command and some to obey. Some wish to "get on" and others are perfectly content to remain in a groove. Some have high mental gifts and others high moral gifts. Some, on the other hand, have slow, stolid natures, fitted for little else than simple physical effort.

The field of the third principle will now be clear. It concerns the study of the personnel of the industrial plant *in their capacity as human beings,* and with a view to their improvement as workers. It covers the consideration of the conditions *external* to them, by which they are necessarily influenced; and it covers the study of their *inner* qualities, by which study we avoid putting the round pegs in the square holes. Further it embraces the study of incentive, by which we direct the energies of each individual into the precise path of most advantage to the organization.

The principle of the Promotion of Personal Effectiveness is the youngest of all the principles of administration. It is as yet only in its infancy, and its possibilities are far from being fully understood. In former days it had only one branch, viz.:—the use of the goad. This was superseded by the simple principle of dangling the carrot before the donkey's nose. Neither of these primitive methods will work today. The direction in which the application of this principle is tending in modern plants is that of making the individual comfortable in the first place,—that is, removing all avoidable bad conditions from his neighborhood; seconly, determining what qualifications are desirable for each task or duty, and selecting candidates who possess those qualifications in superior degree; thirdly, providing appropriate incentive so adjusted as to reward the exercise, as a matter of habit, of just those special qualifications.

Beyond the consideration of the individual it comprises consideration of the mass. *Esprit de corps* must be fostered. It is the *orchestration* of Effort that is our aim, and therefore the mutual relations of men must be carefully studied and adjusted. Each man must be, in a practical degree, *persona grata* to the men with whom he comes in contact. Team work rests on a basis of mutual respect, or at least mutual tolerance. Discordant notes must therefore be eliminated. All these matters have as yet received little attention. Systematic study of the Promotion of Personal Effectiveness is the great work of future years.

Conclusion.

We have now enumerated and briefly examined what may be fairly considered as the main guiding or regulative principles of all varieties of manufacturing administration. They may be tabulated as follows:—

The exercise of Effort in manufacturing industry is subject to three regulative principles or laws summarized in the table on page 111.

These are universal principles, common to all forms of manufacturing industry, and are as true in a textile mill as in a machine shop or a shoe factory. They are probably, indeed, of universal application in every case where associated groups of men are organized for any definite work. In other words, if experience proves that they have been correctly stated, they may be regarded as true laws of effort.

Properly applied they will be found to be important aids to practical administration, inasmuch as they point out what to look for, what precautions must be taken, what dangers should be avoided, and what advantages may be realized, in organizing or managing a plant.

TABLE VII. THE LAWS OF EFFORT.

1. Experience must be systematically accumulated, standardized and applied.
2. Effort must be economically regulated:—
   - 2a. It must be Divided.
   - 2b. It must be Co-ordinated.
   - 2c. It must be Conserved.
   - 2d. It must be Remunerated.
3. Personal effectiveness must be promoted:—
   - 3a. Good physical conditions and environment must be maintained.
   - 3b. The vocation, task, or duty should be analyzed to determine the special human faculty concerned.
   - 3c. Tests should be applied to determine in what degree candidates possess special faculty.
   - 3d. Habit should be formed on standardized bases, old or new.
   - 3e. *Esprit de corps* must be fostered.
   - 3f. Incentive must be proportioned to effort expected.

Chapter VI

PRACTICAL APPLICATION OF THE FIRST LAW OF EFFORT

"A NEW organization," says a recent writer,* "is *new* in a limited sense only. It uses men of experience. It uses existing machines and implements. It follows existing methods of conducting business and in the general management of its affairs." No more succinct description of the field of the first law of Effort, viz., that *Experience must be systematically accumulated, standardized and applied,* could be given.

In beginning any enterprise, the first thing to be done is to ensure that the start is made at the highest level of attainment yet known. We must not equip ourselves with an out-of-date plant, with inexperienced officials, with imperfect materials or with ancient and discarded methods. To do so would be, in all probability, to fail after a brief career of struggle against odds. But to avoid all this

* Human Factor in Works Management, by James Hartness, p. 46.

it is necessary to become closely in touch with what others have done before in the same line of effort. We must adopt the best current standards. Having ascertained these, having accumulated this experience, we must next reproduce it in action or, in other words, apply it. In proportion as we are successful in this task, our chances of success will be increased.

Similarly, in conducting our business from day to day, we shall have two kinds of experience to accumulate and apply. One kind will refer to what others outside our own undertaking are doing, the other kind will refer to changes and happenings within our own plant. These streams of experience will need to be collated, and the lessons they teach transmuted into revised standards and new practice when necessary. We shall find that in each of the five organic functions we must be on the outlook for a different kind of experience to accumulate and apply.

What does this mean, expressed in practical language? It means that as regards the five organic functions we must provide a separate series of standards, and that these must not be merely set up when we commence operations, but must be continually brought up to date and improved, by the results of the experience of others and of ourselves being incorporated with them. Thus we shall require standards as to design, as to operation, and as to equipment, control, and comparison. Very little consideration is necessary to realize that the highest and best standards are necessary in all these functional activities, and that these standards are wholly independent of each other. High standards of comparison may exist alongside lax standards of control, in which case the lessons taught by exact comparison will probably be wasted, for they will never be translated into new effort. In other words experience will be *systematically accumulated,* but it will not be *applied.*

Similarly high standards of operation, extremely skilful workmen, fine machines, efficient processing, may exist alongside lax standards of design. In such case the efficiency of operation is not impaired, but the total efficiency of the plant as a whole is impaired. High efficiency of design can only be brought about by careful observation of the laws of effort as applied to the function of design, and so with each of the other functions.

(a) Standards in Regard to Design

At the outset the division of Design into design for technical use and design for manufacture must be observed. Although we are considering the latter alone in this inquiry, it may be mentioned that the first law of Effort applies to design for technical use also. For example, in placing a new machine or product on the market, the performance of existing machines or the qualities of existing product with which we have to compete, create Standards which we must at least equal and if possible surpass. Similarly it is obviously necessary to be on the alert as to all improvements made by our rivals, and to study out improvements of our own if we do not wish to find ourselves some day in an unfavorable condition for survival. This is to say that we must, as regards the design for technical use of our product, systematically accumulate and apply all the experience possible, so that the product does not become inferior and get passed in the race.

In regard to design for manufacture, which is the sphere of the organic function of Design as treated here, it is also necessary systematically to accumulate experience and set up and apply standards. The standards which we apply here will, in fact, exert a most powerful influence on the fortunes of the plant, because as pointed out in a former chapter, Design sets in motion a long chain of Effort, and if it does not do so efficiently, no degree of high efficiency further along the line will ever be able to compensate for the original errors of method introduced.

What are the directions in which design for manufacture should accumulate and apply experience? As this aspect of Design is an internal matter, the Experience to be sought is a thorough knowledge of the operation units—the machine processes, trades and skills represented in the shops—of the transport facilities, in the case of large size product, of the various machine accessories necessary to production under certain conditions. As design for manufacture consists in so arranging the units of product that they correspond exactly to the facilities for manufacture present in the plant, it is obvious that too much cannot be known about such facilities by the Designer. Then there is the further question of what parts should be made and what purchased, what parts are kept in stock and what parts must be made specially. All these questions will be discussed later, but the point now to be emphasized is that they should all be systematically gone over, and a standard practice set up, which practice should become the working tradition of the office. The more standards of this kind that are established, provided they are wise and well thought out standards, the smoother will be the work of design, and the fewer will be the errors, omissions, and unnecessary work caused by unsystematic and unstandardized practice.

(b) In Regard to Equipment

Both in the installation, and in the administration and maintenance of Equipment a large field exists for the systematic accumulation, standardization and application of Experience. In erecting a plant a knowledge of the standards already recognized and established is essential if our plant is to be one of the highest possible efficiency. We must find out the most advanced practice in each department of Equipment, collate it with our own experience or that of a competent expert, and make our plans accordingly. Plants now building, for example, embody very different ideas as to day lighting, artificial lighting, power generation and transmission, and as to transporting and storage arrangements, from those erected ten or twelve years ago. The dark, dismal and dirty shops of the past are being superseded by light, bright and airy shops. A forest of belting, with its inconvenient brushwood of counter-shafts and pulleys, is no longer the salient feature observable when entering a modern shop. In some industries the confusion caused by a crowd of help carrying things about has been banished by silent smooth-working conveying appliances. And many other instances will occur to everyone.

What does this change imply? It is simply that much thought, much systematic study has been given to all these matters. Experience has been accumulated with regard to each, with the result that new standards have arisen and have become accepted. In erecting a new plant we must obviously search out and apply these standards, or our plant is likely to be inferior in some respect.

In the administrative aspect of Equipment, similar conditions apply. The generation of power, for example, is a matter which fairly bristles with standards, and while it is the sphere of the organic function of Comparison to make observation of the data regarding the daily working of the power plant, the utility of this observation will depend entirely on how far we make use of it to compare with standards.

The less definite matter of maintenance and repair has no such general standards as, for example, pounds of fuel per pound of steam in the case of the power plant. But even here, we have a natural standard—freedom from breakdown—which can be set up, and departures from it systematically noted and studied. On the other hand the maintenance of heating temperature has, of course, an exact standard, viz.:—the degree of heat specified as measured by the thermometer. Similarly all the various physical conditions which it is the business of Equipment to maintain can be brought under this law. As regards all of them, experience can be systematically accumulated, standards set up, and these standards revised from time to time in the light of new experience.

(c) In Regard to Control

The use and application of the accumulated experience of the past with regard to systems of control is not so easy. Most plants start on a small scale; and as we have seen, Control tends in small plants to be simple and rudimentary. There is but little definite and scientifically based experience in the past to adopt. Systems of control have up to the present been arbitrary combinations, growths rather than structures, strictly adaptable only to the particular business in which they were developed.* We could get *ideas* from observing existing systems of control but we could not get definite working rules for guidance. Nor is it possible to get much help from the various theoretical systems put forward of late years. These are for the most part arbitrary combinations also, having a limited area of application, and adapted to few industries. They have been in some cases very important contributions to the subject of administration, but after all they are specific combinations and not universal principles.

In any case a small plant just starting cannot have a highly developed organ of control, just as a baby does not have as large a head as a full-grown man. But while the

* It will be remembered that as industry progresses, the other organic functions are definitely devolved and given shape, but Control remains to the last and is the last to be systematized.

child's head grows larger automatically, a system of control is just as likely to grow wrong as to grow right. One of the most important services which the reduction of management to a correct classification of functions and regulative principles can offer is the demonstration of the "why and wherefore" of each department of organization. Then, and only then, will the beginnings of Control be established on such a basis that they can be developed harmoniously as the business increases in size, and a source of disturbance thereby eliminated.

All this means that standardized practice in regard to Control is as yet not very definite. What standards exist are negative rather than positive. "No man can serve two masters" is one of these, or in other words, we must avoid the clashing of authority, and must establish clear lines of subordination throughout the plant. The idea, taken from military organization, of "line and staff" is to some extent a standard of Control, but only large plants can develop such a system. In applying it, a danger exists of confusing executive with advisory functions, that is, of giving executive power to the latter, which is a dangerous practice.

But while definite standards in the installation of control systems are as yet somewhat scarce, when we come to the administrative aspect of Control, the law that experience must be systematically accumulated, standardized and applied has a definite sphere. Few systems of control work perfectly, but they can be gradually improved if every instance of a hitch is recorded and studied, its cause ascertained, and new standard practice set up of a kind to eliminate the defect. While a "self-perpetuating system" is a myth and contrary to common-sense, nevertheless a considerable amount of self-adjustment to changing conditions can be made, if the application of this first law of Effort is kept in mind.

(d) In Regard to Comparison

The organic function of Comparison is more fortunate than that of Control, inasmuch as its methods have reached a higher degree of standardization, and a more settled condition of practice.

The different Standards in the technical sphere of Comparison, both chemical and physical, are necessarily definite and exact, and our search for experience will rather be in regard to methods of ascertaining them than otherwise. In the accounting sphere the methods available for adoption, though lacking the extreme precision of technical methods, are nevertheless highly developed and well-known. Methods of recording time, quantity, number and value are many, and in many cases bound up with the use of special appliances of a labor-saving character, but they are in all cases definite, and only require study to enable the right method to be selected as a standard.

But while the *methods* of Comparison are fairly well standardized, the objects of this function are by no means so generally agreed upon. *What* should be recorded and *why* it should be recorded appear at present to be matters of personal taste, though of course it should not be so. We shall return to this subject later, and all that is germane to our present subject is to point out that while experience as to methods is available in plenty, it is generally lacking in regard to the objects to be attained by recording and comparing data. Every plant can however set itself systematically to accumulate experience about its own needs in this respect, and so set up and apply its own standards.

(e) In Regard to Operation

Finally we come to the organic function of Operation. Here we may or may not be able to draw copiously on the experience of the past, when settling the methods to be followed in a new plant. In some industries the fundamental principles of Operation are already determined, particularly those industries in which the processes are largely scientific, such as chemical manufacture, steel making, paper making, sugar manufacture and so forth. But in other cases only empirical practice exists, unilluminated by any thought of working principles. In machine work, for instance, the classical researches of Mr. Fred W. Taylor showed how far the apparently simple operation of cutting metal is really affected by quite a large number of factors, each of which must be understood and allowed for if the highest efficiency is to be realized.

Operation, as has been pointed out in a former chapter, is the function in which the greatest differences exist between one industry and another. It is only by chance that the operative methods of one industry can be applied to another industry. All the other functions must obviously have common principles, because in all industries their aims or ends are precisely similar, but the technical operation of making steel rails has probably not one single point in common with the making of silk neckties. The end in view—namely, rails—is entirely different in every respect from the other end in view—namely, neckties. It is *the dissimilarity of aim,* and not merely the nature of the materials, that makes it impossible to suppose that common ground can be found to exist in industries so wholly dissimilar as those suggested in the example above.

Nevertheless this does not prevent the first law of Effort from applying to Operation in the fullest degree. If we wish to make neckties, we must first accumulate all the experience we can gather on the various operations concerned. So with any other product. Only our task will be much greater in one case than another. To master thoroughly all that is known about the operation involved in the making of dynamos is a bigger task than it is to master all that is known about the manufacture of steel tanks. But the principle is the same in both cases; namely, to accumulate all the experience possible, to standardize it, and apply it.

(f) Application of Experience in Running a Plant

Thus far we have considered mainly the use of experience in organizing or setting up the various functions when starting a plant. But the principle applies with equal force in running a plant, although not so obviously, since everyone would scout the idea of not starting a plant on the best known lines, while afterwards there is a tendency to consider that experience has little more to teach us. While therefore the application of the first law of Effort in regard to new plants is merely a platitude or a truism, which many people will not think worth setting down on paper, its application to plants in operation is a different matter. In every one of the separate fields of Effort represented by the organic functions, progress is possible, both on our own part and on the part of other plants. The technical side of any industry is not alone progressive; progress is constantly being made in the organization of all the functions—in methods of Design, in arrangement of Equipment, in means of Control, in processes of Comparison, as well as in the technics of Operation. Standards on all of these are constantly being improved and therefore constantly being superseded by new and higher ones.

WHERE THEORY TOUCHES PRACTICE

TABLE VIII. APPLICATION OF THE FIRST LAW OF EFFORT

The Law:—Experience must be systematically accumulated, standardized and applied.

In Design. Application of the Law to the function of Design implies that all similar products should be scrutinized and their advantages and defects analyzed. Their performance or value, commercially, forms a standard which we must at least equal. In Design for manufacture experience as to the character of the operation units, and as to what parts are purchasable, which are stocked, etc., must be assimilated by the designer. This information is embodied in standards of designing practice, which should become traditional in that office.

In Equipment. In installing Equipment, the experience of others, or of oneself, in the past must be drawn on so that the most perfect types of appliance are selected. They must also be arranged in the most efficient way. The best known practice of the day is thus a standard which we set up and follow, and must later supplement and improve if possible. In administration of Equipment, various standards of performance for such equipment exist, and must be applied regularly and, if possible, surpassed.

In Control. Experience should be drawn on when settling the plan of Control, but true standards of Control are very scarce. Moreover, Control needs to expand, and is therefore more difficult to standardize than the other functions. Each plant can, however, accumulate experience in controlling methods for itself, and thus accomplish a measure of self-adjustment. Owing, however, to the difficult nature of the task, the professional adviser will probably always find his largest opportunity in this field.

In Comparison. Comparison employs technical and accounting methods in the selection of which experience must be drawn on. Each of these methods then becomes a standard for that kind of work. The selection of objects for Comparison—that is, *what* must be compared—is a matter very far from standardization at present. Each plant can accumulate experience for itself on this point.

In Operation. The existing processes of Operation in the given industry should be scrutinized and the best methods selected at starting. Technical progress in some industries is rapid. The law of accumulation of experience is therefore very important in this function. Operation standards are subject to constant improvement, and must therefore be the subject of continual observation and study.

Ceaseless vigilance is the price of progress as it is of liberty. The first law of Effort—that Experience must be systematically accumulated, standardized and applied—is merely the expression of this truth in another and more complete form, since the actual *use* of experience is the important thing. But the foregoing arguments will have been presented to little purpose if it is not obvious that *what we have to do is* NOT *merely and generally to accumulate Experience,* but that this experience must be of five different and independent kinds, gathered from different fields, and indeed gathered and applied by different persons for the most part; namely, experience as to Design, as to Equipment, as to methods of Control, as to ways of Comparison, and as to technical Operation.

This, perhaps, is the first striking application of the organic basis of Administration—the recognition that our organic functions are not merely nomenclature, but that *they embody five different kinds of experience, which must be both gathered and applied independently.* Here we descend from the abstract to the practical in a breath, we observe that our functions correspond to something real, something in the nature of things, which like all natural facts is worthy of attention. Applying the first law of Effort to these functions in turn, we see that though it applies to all, it produces different results in each. In each it creates a new store of knowledge, new materials for progress; but these stores and these materials are of quite different nature in each function, and have their application in quite different fields.

Chapter VII

PRACTICAL APPLICATION OF THE SECOND LAW OF EFFORT

THE second law of Effort deals with the Division, Co-ordination, Conservation and Remuneration of Effort, or more generally, with its regulation in the economic sense. This may be described as the motor principle of Effort, inasmuch as it deals with effort in action—effort actually engaged in performing work. The first law, "the accumulation and application of experience", is obviously static or preparatory in its nature; the second law, "regulation of Effort", is just as obviously active and dynamic. As each organic function has its own special purpose, the law will apply to each of them in a different way and the consequent reactions will obviously be somewhat complex. Nevertheless as the second law of Effort is the most important of all, its action must be very carefully studied.

Before considering the specific working of the law within each organic function it is desirable to consider the tendency of each sub-principle in the abstract. These tendencies may be briefly summarized as follows:—

Division is the analytical principle. It decides the nature of the units to which Effort is to be applied, and thus determines the direction of Effort.

Co-ordination is the synthetical principle. It requires that all the divided units of Effort, taken together, shall amount to the result desired, exactly, *i. e.,* without either gap or overlap.

Conservation is the quantitative principle. It demands that for the given purpose the minimum amount of Effort should be used. It seeks to eliminate wasteful methods.

Remuneration has to do with ascertaining, in each organic function, *what is the particular feature of Effort* that is to be encouraged and rewarded.*

Each of these ways of regulating Effort has application in each of the organic functions, and no function can be considered as correctly organized unless the application of

* The *form* of the incentive (bonus, premium, etc.) belongs to the general subject of Incentives to Effort. See third law of Effort—the "Promotion of Personal Effectiveness," Chapters IX, X and XI.

each of the sub-principles of the law has received due attention.

(1) Effort Must Be Divided

The idea of division of *labor,* meaning, for the most part, operative labor, is an old and familiar one. It is generally recognized as a predominant factor in industry, and a large share of modern industrial progress is usually attributed to the growing development of this principle. The term "division of Effort" has, of course, a wider application than that usually implied in the use of the older phrase. It applies to all the organic functions and not merely to operation. It is easy to picture Product reduced to ultimate units (parts or components) or Operation reduced to unit processes of minute sub-division, but these are only a small part of the practical applications of the division of Effort. The latter applies not only to things that we can see and handle, but also to mental tasks, to duties, to the spheres of personal relationship in a system of administration, and in short, to the work of each and every function.

Division of Effort is the *analytical* subprinciple of the second law of Effort which demands that "Effort must be economically regulated". In practice it implies that all activity should be divided into units of "simplest skill". In each organic function we must seek such units, and in each they will necessarily be of a different kind. But while the division of *labor* is a comparatively easy matter to compass, for reasons which will appear when we discuss Operative Effort, the division of Effort in the other functions is a more difficult matter. We must never lose sight of the fact that division of Effort by itself means very little. It requires to be corrected or controlled by subsequent application of co-ordination and conservation before an efficient regulation of Effort is arrived at in any function.

Division of Effort in Design.—Division of the *act* of design is only possible, or at any rate only realizable in practice for the most part, by subdividing the *object* of design, or in other words the Product. While no doubt a certain amount of collaboration in designing is possible, this will depend so entirely on particular instances that it cannot be considered as a matter of administrative science. We cannot lay down any rules on the subject, for the obvious reason that the inventive faculties have laws of their own, which few men understand even in their own case. Practically, therefore, when we speak of division of effort as applied to design, we refer to ultimate units of product and not to ultimate acts of design.

In speaking of Design throughout this discussion, it must also be remembered that *design for manufacture* is alone referred to. As pointed out in Chapter II, the efficiency of any design for technical use, *e. g.* the efficiency of a particular design of pump for pumping purposes, or the efficiency of a particular design of printing press for three-color work, is entirely outside the science of *manufacturing management.* It is purely a matter of technology. The sphere of work embraced in this discussion is that of efficiency of *manufacturing* alone. Now the pump and the press may be technically successful or they may not, but whether they are or are not, the question of their economical manufacture is obviously an entirely separate matter. The science of manufacturing management will point out the way to make any product whatever, in the most economical way, consistent with the technical knowledge available; but it will not add a hair's breadth to that knowledge. The most perfect *manufacture* will not enable the pump or the press to excel its competitors in technical value—that will depend entirely on whether its technological principles are correct, or in other words upon its design for *use.*

So many persons confuse management with technology that the difference between them cannot be too often insisted upon. A man having the habit of authority, and a profound experience of human nature may become in turn a successful military officer, and a prosperous lawyer or man of business, but the technology of the arts of war and of peace are, notwithstanding, very different. His success will be in proportion as he carries over from the one pursuit to the other, just those fundamental powers of understanding and persuading or controlling men which are independent of any technology.

So in the industrial field, the technology involved in the operations of each industry differs greatly; it even differs to a considerable degree between plants in the same industry. But the art of management rests on the same foundations in all industries. If it were not so, no man could be successful in more than one industry as a manager, yet the contrary is proved every day. A man cannot carry in his head more than two or three separate technologies, but he can control several quite distinct kinds of plant, because he carries over, unconsciously for the most part, principles of action which are common to all plants, and applies them to the special cases as he meets with them. This book is an attempt to reduce these common principles of the art of administration to definite knowledge. It will therefore be obvious that questions of technology do not properly enter into it.

Division of Effort in Design, then, relates to the splitting up of Product into ultimate units for manufacture. We have seen that at its fullest development design for manufacture frequently comprises three distinct acts with regard to the same piece or component. There is design of the part itself, of the special appliances by which it is to be made, and specification of the standard routine of Operation.

As regards each unit of Product, the processes by which it is to be made must coincide exactly with units of Operation (See later). In many industries this is a simple matter, since no alternative ways of doing anything exist. In other industries, as in engineering manufacture, there may be many ways of attaining the same result, and the selection of one or other may depend upon conditions well within the sphere of the designer to vary. The application of the principle of division of Effort to Design has, as its most significant feature, the necessity of keeping in mind, while the design of any part or component is going on, exactly how it is to be manufactured. This, of course, implies the picturing of each kind of Effort that will subsequently be necessary to produce it. And this, in turn, means that the designer will seek to keep such subsequent Effort in as simple a form as possible.

Division of Effort in Design means, then: (1) analysis of the Product into simplest parts or components; (2) applying the units of Operation (*i. e.,* processes) to each part in the most direct way; (3) simplifying such application of processes by special means if necessary, such as providing lugs or ears for holding while under operation, or special holding devices, jigs and so forth.

Division of Effort in Equipment. As regards Equipment it will be evident that the units to be sought are wholly different from those of Design. Equipment is the organic function that provides *conditions* preliminary to manufacture. It has to do with buildings, and the utilization of their space economically; with the provision of adequate power plant; and with craneage, transporting and conveying appliances. Further it has to maintain all these things as "services" to production, so that favorable conditions for manufacture may not merely be installed but kept up. Finally it is responsible for the maintenance and repair of the operative equipment itself, and for the keeping of the whole plant in running condition.

Primitively, it will be remembered, an "odd man" of a mechanical turn attended to all these matters. That is as far as they received any systematic attention at all, in primitive conditions of industry—and in some industries that would feel insulted if that appellation were applied to them, the problem is greatly simplified by attending to nothing until a breakdown or interruption of some kind occurs. But in large-scale manufacturing we cannot afford to leave things to look after themselves in this way, and as the field of Equipment is a large one, division of Effort becomes a very obvious necessity.

The problem of Equipment has two sides, its installation and its current working. As a matter of strict accuracy, all the organic functions should be treated from these two points of view. Each has to be installed and also conducted as a going concern. But most of the functions are more fluid than Equipment; they are made up of persons and their relations rather than things, so that to dwell on their installation is hardly necessary in an elementary manual. But Equipment is so obviously linked up with heavy material objects that the problems of their installation and their use become almost equally important. In fact we could hardly deal satisfactorily with the latter without considering the former.

Space or area, power, and transport are the three principal features of the installation of equipment, outside the operative equipment itself. Division of Effort in regard to these means the apportionment to particular uses, of the space available, installation of equipment for the generation and transmission of power to the points wanted, the arrangement of storage and transport appliances in the right places.

Administratively, or in regard to the current use of Equipment, division of Effort is, again, into units of simplest skill. The broadest division will be into "services" corresponding with the prime kinds of Equipment.

Thus one such prime "service" will take care of the buildings, their repair and cleaning; another will be occupied with running the power, lighting, heating and ventilation; another with operating the transport appliances; while still another will be devoted to keeping the mechanical equipment of all kinds in repair. In some cases a special department might be concerned with making and installing new machines and equipment, but this is rather an offshoot than a regular part of administrative activity.

In large plants, the division of Effort would be carried much further than this. Special men would be told off to maintain belts, others to look after motors, others again to oil and maintain shafting, and so forth. The farther such subdivision can be carried, as long as it is not forced, the more efficient is the result likely to be.

Generally speaking the division of Effort in the use of Equipment means the specialized care of particular *conditions.* It begins by an analysis of the elements of these conditions, and applies separate and appropriate effort to each. If successfully applied it means that conditions are kept *uniform.* This is by no means a matter of course in practice, at the present time.

Division of Effort in Control. Control, like Equipment, has a side so entirely antecedent to current administration that it must be treated separately. The installation of Control is an obviously different matter from its daily routine. Installation of Control is in fact a very delicate problem, quite as much so as is the proper choice and arrangement of Equipment. In both cases the mechanism must be installed before it can be worked.

Division of effort in Control means the analysis of personal duties throughout the plant. These duties, once more, must be reduced to units of simplest skill, as far as possible. We must begin by considering the elementary facts of Control, and then group these in a hierarchy, or system of subordination, so that at each stage the degree of supervision required represents a definite grade of qualification, neither more or less than is necessary.

Having done this, and arranged or mapped out the personal relations of staff (for it is by setting up correct personal relations that Control is exercised and maintained) the current or administrative side of Control may be considered. In practice this has to do with the routine handling of Orders. A diagram of the personal relations of the staff may be likened to the map of a watershed, with all its rivers, streams, tributaries, canals and estuary; and Orders may be likened to the water that flows through these various channels. The rivers and streams are there for the purpose of conducting water. The system of Control is there for the purpose of transmitting and giving effect to orders. Division of effort in this department, has, then, to do with the analysis and dissection of orders and their transmission to all concerned, in such a way that each attends to his own particular duty with regard to each order.

Division of Effort in Comparison means the setting up of comparison units. The nature of these will vary with the type of industry. Generally speaking, they are the elementary facts of Operation and records of the routine work of the other functions. The most obvious example of the former is the

Time Sheet, or in other words the record of how each man has been occupied, what he has done and how long he took to do it. The next most obvious unit fact of Comparison is the consumption of material, what material it was, what it was used for, and how much was used.

These trite illustrations are introduced for the purpose of calling attention to the fact that the units of Comparison are, for the most part, *complex units.* They are records of single *transactions,* or should be, but more than one thing is required to be known about each such transaction. This is very little understood, with a result on the one hand of frequent inefficiency in accounting, and on the other, needless complexity of system due to the right facts about unit transactions not having been recorded at the time of their occurrence.

The units of Comparison are then, transactions; and the whole art of Comparison rests on making the right kind of record about them. Unfortunately, while a great deal of attention has been devoted to methods of working up supposed unit facts, and their presentation in tabular statements, returns and reports, very little study has been given to the question of how, why, and when to obtain them at their source. Yet this is the really important point. Unless these Comparison units are accurately collected at the time of the transaction, but little reliance can be placed on the results of their working up into statistics.

Comparison units are of two kinds, those relating to quantities and values, and those relating to properties and dimensions. Record and verification of these latter is usually called testing and inspection. The units concerned are wholly dependent on technical considerations, and need not be discussed further here.

Division of Effort in Operation.—In Operation the units of division are usually skills or trades, generally but not always represented by the operation of a machine. In other words they are processes. To manufacture a product we require a succession of processes, and when these are subdivided into elements of simplest skill *as far as possible,* units of Operation result. The work of Design, as mentioned above, must always be in strict agreement with these units of Operation. The tendency in Operation is always towards further and further division of effort into forms of less and less skill. The ultimate tendency of this is towards the elimination of operative skill altogether, and its embodiment in a machine. (See axiom I, Appendix V). In some industries this has practically been accomplished, no operative skill being left. In others, as in shoe-making, division has been carried to a high degree, but considerable specialized skill is required to work some of the machines effectually.

TABLE IX. APPLICATION OF THE SECOND LAW OF EFFORT.

Sub-section I. Effort Must Be Divided

The second Law of Effort has, as its first sub-section, the analytical principle that Effort must be Divided. This implies that all work must be analyzed into units of "simplest skill". In each organic function this sub-principle of the law delimits the units to which Effort is to be applied, and thus determines the direction of Effort.

In Design:—Means subdivision of the *object* of design, viz.:—Product. Means, therefore, analysis of Product into simplest parts or components. On each of these parts Operation has to be undertaken, and therefore design of parts must keep in view the nature of operation units. When, further, the routine of operation is specified in advance, it must be specified strictly in terms of operation units. The application of processes must be facilitated where possible by modifying design to allow direct and simple operation. Design for manufacture has no relation to technological efficiency of the complete Product.

In Equipment:—(1) *Installation* means apportionment of space available, and analysis of the different kinds of equipment-service that will be required. (2) *Administration.* Division of the services of Equipment into units of simplest skill—special men being assigned as far as practicable to special duties, such as care of belts, motors, shafting, cleaning, repairs of different classes, and so forth.

In Control:— (1) *Installation* means allotment of duties in units requiring simplest qualifications for each. This applies all the way up. Each duty should represent a definite grade of qualification, neither more nor less than is really necessary. (2) *Administration* implies the dissection of orders into units corresponding exactly with the work to be done on them by the various organic functions and their internal subdivisions.

In Comparison:—Means the definition of what are the units requiring measurement and record. They are found to be transactions, but about each transaction more than one fact is generally required to be known. Comparison units are, therefore, *complex* units, and on their accurate delimitation the success of the accounting costs will depend. On the technical side, Inspection units are dependent on specifications of a wholly technical nature peculiar to each industry. In some cases they imply accurate measurement, and in others chemical analysis, at various stages of manufacture.

In Operation:—Operation is the exercise of manual trades and skills, including the manipulation of machines. To manufacture, all the necessary trades and skills must be present, and the exact sphere of action of each fully understood. Design must specify its working instructions in terms of the trades and skills existing in the plant. Division of Effort in operation means the use of methods requiring the (successive) application of simple skill, and the elimination as far as possible of methods requiring rare and high-priced skill.

Remarks on Division of Effort.—We have now passed in review, briefly, the influence of division of Effort on the activities exercised in the five organic functions. Most of these influences will be familiar, because the idea of division of Effort is fairly well understood, especially in regard to labor itself. It will be seen however that the principle is by no means limited to the division of labor, its units are not all labor units. In each function the principle, applied to the work of that function, gives rise to a different kind of unit, this unit being the ultimate practical division of that kind of work.

Having observed the influence of division of Effort we shall now pass to a much less understood principle, that of co-ordination of Effort. This has already been defined as the converse, or even as the antidote to Division. The latter is an easy and familiar process, but it needs to be safeguarded by attention to the principle of co-ordination, to be economically efficient.

(2) Effort Must Be Co-ordinated

Application of the sub-principle, that "Effort must be co-ordinated", assists us in safeguarding against the danger of "gaps and overlaps", arising out of the original necessity to subdivide Effort. This danger is always present when Effort is divided, and is equally present in regard to all the five organic functions.

Co-ordination of Effort in Design.—The importance of co-ordination in regard to Design will be great in proportion as there has been great division into components or units of Design. In some industries there is very little danger of "gaps or overlaps"; in other industries there is considerable danger. In a chemical industry, for example, such as soap manufacture, the adoption of a new formula (which occupies the place of a design) might or might not imply new division of Effort; that is, it might or might not employ exactly the same machinery and stages of process, but there could hardly fail to be complete co-ordination, because if there were not, some different product from what was intended would result. That is, as far as the chemical part of the process of manufacture is concerned. On the other hand it might possibly happen that the new product had characteristics that would prevent it being handled freely by the subsequent printing, cutting and packeting machines, and in that case a true want of co-ordination of design would be reached.

In mechanical industry on the other hand, "gaps and overlaps" are of frequent occurrence, and co-ordination, instead of being almost obvious, requires minute precautions to bring it about successfully. In practical language this means attention to the question of "limits, fits and tolerances" as regards each unit. In mass production, or any production where the same article is made over and over again, the elimination of imperfect co-ordination should reach a very high standard, if the cost of extra fitting and hand work on unit parts is carefully recorded and scrutinized, since this will point out just what parts are in need of more accurate specification of limits and tolerances. But this practical application of the first law—"the accumulation and application of experience"—is not always made in the right way. Frequently, the co-ordination is brought about by what may be called "unofficial" means, by one man telling another to allow a thousandth here or a sixty-fourth there, and the practice of doing this then becomes one of the traditions of the shop, one of the subtle "secrets" of operation, possession of which sometimes "puffs up" the possessor.

This by no means imaginary case illustrates the process by which "vested interests" grow up in a plant, and how some very wise shop official has ultimately to be appealed to in cases where the executive should be intimately in touch with the matter in dispute. It goes without saying that want of co-ordination of units is an expensive fault, not only in its direct consequences of extra expense in fitting, but in disturbance of routine, and in the setting up of arbitrary standards of manufacture.

The right way to cure imperfect co-ordination of Design is to scrutinize all dimensional relations of the unit part as carefully as possible to begin with, and then to correct and modify these dimensions on the drawing from time to time as experience suggests. In other words the practical shop experience of the necessities of Co-ordination should be incorporated in corrected design, and not left to become an arbitrary and obstinate tradition in the shop.

Co-ordination of Effort in Equipment—In regard to *Installation* of Equipment, Coordination implies a correct balance of the different kinds. Each kind must be present in the right proportion and in the right quantity. Each Department must also be allotted the proportional amount of space fitted to its needs. These matters are generally given attention when a new plant is being started up, though even then, too little attention is frequently given to the subsidiary departments and equipment, such as storage equipment, convenient and well-planned methods of handling product, etc. But the most frequent fault in installation of the organic function of Equipment is disregard of the probable necessity for expansion. It is too frequently overlooked that an increase in business will bring in its train expansion of the subsidiary departments as well as the shops. The result of this is often disastrous.

It is not sufficient to enlarge the function of Operation alone when business expands. If the different sections of Equipment were correctly balanced at the beginning, it is evident that increase in output will disturb that balance. The practical result of this is, frequently, that the subsidiary Equipment becomes overtaxed. Power supply becomes inadequate, storage facilities are over-crowded, product accumulates in nodes instead of running in a continuous stream. The era of errors, vexation, and confusion not infrequently sets in after an expansion has been made in the operative department simply because the various kinds of Equipment are no longer in exact co-ordination.

The proper balance of the operative equipment itself must also be considered here. What we have already said as to the balance of Equipment generally, applies in full force to operative equipment. To begin with, the due proportion of the various machines, benches and assembly floors must be worked out with exactitude. But though this is usually done, the troublesome problem of growth is usually settled by being disregarded. One fatal result of this is very often found by industrial engineers when examining a plant, namely the placing of new machines rendered necessary by the expansion of the business, in all sorts of corners and odd places. This means that even if the path of travel of the work was originally direct and efficient, it has become irregular and inefficient, with resulting confusion, worry and loss of time.

The path of travel of product, which was originally without gap or overlap, gradually comes to look like one of the lines traced by the pendulum of an oscillograph.

Administratively, the co-ordination of effort in the function of Equipment implies that the various indirect services arising out of this function are balanced also. Equipment in its administrative aspect provides current or daily and hourly conditions; it is responsible for power supply, for maintenance of temperature and purity of atmosphere, for lighting, for sanitation, for fire protection, and for the upkeep of plant and machinery of every kind in a condition of working efficiency. It is evident therefore that co-ordination of effort as regards the services of Equipment must have considerable bearing on success. The right kind of service must be applied in the right place at the right time.

This is not a very easy matter in some cases. All the services of Equipment partake of the nature of the much dreaded "Expense Burden". There is a natural tendency to curtail, if not to starve them. Yet it is evident that all these services must be sufficiently developed to answer all demands.

For if not, then one or more of these conditions will become unfavorable conditions, and will hinder fullest production. The plant in which something is always going wrong, in which stoppages due to breakdowns of one kind or another are frequent, in which discomfort reigns, are examples of plants in which the co-ordination of the services of Equipment has been neglected, and the importance of perfect balance overlooked.

Co-ordination of Effort in Control.—In the *Installation* of Control, co-ordination plays a very important part. In Equipment, as we have seen, a perfect balance of physical conditions is implied. Similarly, in Control we find that co-ordination means a perfect balance of personal duties,—without "gap or overlap". And just as we saw that in Equipment growth of business has a tendency to upset this balance, so in Control the same phenomena are observable. A system of Control that is well planned at the outset of the business, will inevitably require modification and readjustment of the proportions of its component units when the business increases to a marked degree.

The same evil results will also follow, if this readjustment is not made. The increase of work will be felt throughout the whole system of Control, but not equally everywhere. Those duties having more direct connection with physical product will probably feel it first—storekeepers will be overworked, order clerks will be rushed, shippers will be under continuous pressure. The original balance of duties will be upset, and the smooth running of the system rendered difficult.

In planning spheres of duty at the outset, co-ordination demands that every possible duty should be provided for somewhere. There must be no "floating" duties, to be attended to as opportunity offers. What is everyone's business is no-one's business. In other words there must be no "gaps", no duties not definitely allotted. In like manner we must avoid "overlaps"; no work must be done more than once—a truism that is not always as obvious as it appears. When all the various spheres of duty are thus coordinated, a smooth working system should result, but as just pointed out, it will always be subject to disturbance from growth of business, and require periodical readjustment accordingly. The so-called "self-perpetuating system" would be more properly termed a "self-evident absurdity".

From the *administrative* aspect of Control, co-ordination of Effort is seen to refer to the supplementing of the scanty details of Orders. It will be remembered that division of Effort as regards Control implied the dissection or analysis of orders and the launching of the dissected portions in the proper channels, so that each person concerned was informed as to his particular share of work on each order. In practice, however, the separate efforts thus set in motion need some measure of co-ordination depending in large degree on the complexity of the work. In some industries processes are so simple that consultation between the personnel of the different functions is unnecessary, or at any rate need not be formally recognized. In other industries it becomes important.

Co-ordination of Control in regard to orders is frequently accomplished by arranging meetings of important officials or, in other words, by establishing conferences or committees. This however is in itself only a practical application of a general principle that arises out of the necessity to co-ordinate effort in routine work. This principle is that of *Communication*.

Communication between the various officials of a plant needs to be placed on as definite a basis as possible. Regular methods of maintaining it are desirable. There should, for example, be a systematic "mail service" at frequent intervals, by means of which papers and queries may reach their destination automatically with the minimum of disturbance to the routine. For more urgent matters an interdepartmental telephone service is advisable, though its use should be severely restricted to such matters as cannot be conveniently dealt with in the regular mail service.

These facilities are for the most part confined to intercommunication between two individuals, though of late telephone services have been introduced allowing of several persons joining in a discussion. Where more than two opinions have to be taken, however, personal assembly is advisable—hence the conference or committee system. It is a system that must be carefully guarded from abuse.

The chief danger of the committee system lies in its taking away important officials from their regular duties. More than this, such committees are very apt to waste time over the discussion of trifles that should be well within the decision of some single person. The writer has known of a committee, made up of the heads of a very large plant, gravely debating for twenty minutes what kinds and quantities of steel pens should be purchased during the next quarter. The combined salaries of those taking part in the discussion would have sufficed to purchase all the pens required, and still have left five minutes over to discuss other matters. Committees are only valuable when they are wisely presided over, and when the scope of their discussions is closely defined.

Co-ordination of Effort in Comparison.—Co-ordination lies at the very root of efficiency in the function of comparison. The Unit divisions of Comparison are, as we have seen, *Transactions*. About each transaction there are commonly two or more facts to be recorded. Co-ordination demands that all these facts and these transactions taken together shall actually cover the whole ground without "gap or overlap". In practice this is sometimes a matter of some difficulty to ensure.

In some industries the transactions to be recorded are simple, and their co-ordination presents no serious difficulties. The periodical charging of a cupola or a vat with the same materials in the same proportions, day after day, is an example of a simple transaction. The work of a storekeeper or of an inspector is more complex, and just what constitutes the whole record about each of their transactions requires considerable reflection.

The condition that there must be no gap in the records requires frequently that more information should be recorded than there appears any present use for. The elimination of such information should be undertaken with caution, for nothing is more expensive or more subversive of routine efficiency than a call from the executive for information on points about which the record is imperfect or not exhaustive. In large plants where tabulating machines are used for statistics, it is far better to record all possible facts about each transaction, even though there is no immediate use for some of them, because having once placed them on the cards, their subsequent tabulation, even after the interval of months, is a comparatively easy task.

The condition that there must be no overlap is more easy to comply with, though it is very frequently not complied with. In a properly co-ordinated system of Comparison, unit facts should be recorded only once, and in one place. The only further work to be done on such units should be their inclusion in larger groups. We ought not to have independent records made about the same facts, even though they may be wanted for wholly different purposes. Co-ordination means fitting together without gap and overlap, consequently there can only be one proper place for each fact in a complete system of Comparison. The avoidance of copying and recopying of facts is therefore indicated.

A further and most important aspect of co-ordination in regard to Comparison, is in the building up of the unit transactions into a coherent and significant whole. When we ask whether our units of Comparison have been thoroughly co-ordinated, we mean to ask whether the resulting co-ordination possesses *significance*. For just as the division of effort in Comparison runs parallel with its division in actual work, in designing, in running equipment, in storekeeping, in shipping and in operation, so must the final picture which Comparison paints be a recognizable likeness to the *result* of all these different divisions of effort. The first thing that we wish to know is *what* has been accomplished. Now this is obviously a synthesis, because our product is itself a synthesis. After this we may require to know *how* it has been accomplished, which is a matter of consulting detail.

Co-ordination, then, as applied to the function of Comparison calls for accurate delimitation of the sphere of each transaction, so that nothing is left out and nothing is recorded twice; and it demands further that these unit facts shall be so marshalled and arranged that their grouping corresponds to the natural synthesis of actual operations in a significant way.

Co-ordination of Effort in Operation.—Gap and overlap in Operation are not very frequent, for the obvious reason that if they existed in serious degree they would bring production to a stop. It may therefore usually be assumed that the successive processes of Operation have each their definite part to play, and that the sum of these parts is neither more nor less than a complete whole. In a few cases, and in some industries, imperfections of machinery make it necessary to supplement machine finish by hand finish, but such instances are hardly to be regarded as true cases of "gap" in operation. As long as they are unavoidable they form part of the true chain of Operation.

In machine shop work, however, a problem occurs which has some likeness to overlap, though again, not strictly so. Machines of different kind, such for example as planers and milling machines, are capable of doing similar work, and in some cases there is but little real preference to be given to either. Where Design is so expanded as to include the specification of processes, the choice will be made by the department of Design. But in any plant some kind of rule should be worked out as far as possible, so that specific kinds of work shall be confined to one or other of the types of machine. Doing the same thing in the same way is an excellent working rule until, of course, a better way is obvious.

In one respect, Operation is subject to the law of gap and overlap, namely in regard to the "balance" of the machines and appliances it employs. How many of this and of that machine are required to handle the given volume of work is a very nice question, not always satisfactorily answered. But as this is a matter of Equipment, and not of routine operation, its consideration belongs to the section of "Co-ordination of Effort in Equipment" and has already been referred to.

Usually in modern industry, the employment of machinery so dominates the operative function that the question of "balance" as regards the operatives themselves need not be considered. It will be obvious of course that a certain proportion must be maintained between the different kinds of skill involved in the chain of Operation. But as labor is a very liquid element, compared with machinery, very little precaution is necessary in this respect. As long as any particular kind of labor is employed, it is obviously necessary, and when overlap occurs—*i. e.,* when more men of a particular skill are present than are required—the surplus is dropped until the overlap disappears. Gap and overlap as regards labor may therefore be disregarded in practice, as elements to be guarded against.

TABLE X. APPLICATION OF THE SECOND LAW OF EFFORT (CONTINUED).

"Effort Must Be Economically Regulated"

(2) Co-ordination of Effort

Application of the principle that "Effort must be Co-ordinated" points out the dangers of gaps and overlaps, arising out of the original necessity to divide Effort. This danger exists in regard to all the organic functions.

THE SYNTHETICAL VIEWPOINT.

In Design:—Design of the divided units of Product must have reference to their subsequent meeting together. In mechanical work this means careful attention to the specification of limits, fits and tolerances. In any class of work, where components have to be made separately and later brought together, it implies prevision of this necessity by the designer to secure that there is neither "gap or overlap" in the pieces; *i. e.,* that they are neither two large nor too small to fit properly.

In Equipment:—In *Installation of Equipment,* co-ordination means that Equipment must be so planned that its capacity is balanced; *i. e.,* each kind of Equipment, both operative and non-operative, must be present in the right quantity to perform the fullest service required of it.

Administratively it means that the various services must be sufficiently developed to answer all demands. Repairs must not be neglected, nor cleaning overlooked. Each kind of service must be given in the right quantity—neither starved nor over-organized.

In Control:—*Installation.* In allotting spheres of duty there must be no gaps, *i. e.,* no item of routine must be left out of consideration, so that there is doubt as to who should attend to it. Further there should be no overlap of jurisdiction (one man cannot serve two masters).

Administratively, Co-ordination implies supplementing the scanty instructions conveyed by orders, by means of conferences and committees, which discuss the run of the work from several viewpoints periodically. Also as men are not all within speaking distance of each other, it implies the organization of means of communication throughout the plant.

In Comparison:—Co-ordination of Effort in Comparison means the bringing together of unit facts in a significant way. There must be no overlaps; *i. e.,* the same fact must not be recorded more than once. Nor should any record ever be copied. Once recorded the only use of the fact should be its absorption in a larger grouping. There must be no gaps. Every fact likely to be wanted should be recorded, even though no very detailed analysis of them is immediately required.

In Operation:— Operations having similar effects (for example, planing and milling) should be delimited as far as possible, having regard to the nature of the product. A customary use for each should thus be set up and these overlaps neutralized. Gap and overlap in Operation is not very usual, except in such cases as this. In some few cases imperfection of process work makes hand work necessary between processes. Gaps in Operation would be so serious, usually, that the chain of production could not go on.

Chapter VIII

PRACTICAL APPLICATION OF THE SECOND LAW OF EFFORT (*Continued*)

IN the former chapter we dealt with the first two sub-principles of the second law of Effort (that Effort must be Economically Regulated) the first sub-principle being concerned with the division of Effort, and the second with its co-ordination. In the present chapter the two remaining sub-principles of this law will be examined, namely that Effort must be Conserved, and that it must be Remunerated.

(3) "Effort Must Be Conserved"

Conservation is the quantitative principle. Its sphere is that of pointing out in regard to each organic function that there is a particular kind of wastefulness of effort that must be avoided, and conversely that there is a special kind of efficiency of effort to be attained. *Division* of Effort, as we have seen, regulates the primary directions in which Effort is exercised; *co-ordination* demands that all these primary divisions taken together form a complete whole without gap or overlap; *conservation* insists that the minimum amount of effort shall be employed compatible with attainment of the desired end. It is the principle of the "shortest path".

Conservation of Effort in Design.—In considering the unit part of component of product the design of which has been originated by applying the principle of division of effort, and has been examined in the light of co-ordination of effort to ensure that the unit when made will fit into adjacent units without gap or overlap, we have now before us the problem of ascertaining how far we can foresee methods of cutting down effort in the processes of Operation.

If we have a hundred pieces to make, all alike, representing a definite unit of product with carefully specified limits or "margins", it is possible that a variety of methods of making them are open to us. At least this is so in many industries, although in others no such option exists. If we consider mechanical production, however, there will be at least two alternatives—the pieces can be made by hand skill, or they can be made wholly or partly by machines. As there are a hundred to make, the first of these alternatives need not be considered.

The principle that Effort must be conserved leads us to picture to ourselves (1) exactly what operative process will be required to give the shape and dimensions of one piece; (2) how much skilled effort is involved in this operative process; (3) how the fact that this skilled effort is to be applied one hundred times can be altered into a single application of high-grade skill, followed by ninety-nine applications of low-grade skill. This is usually accomplished by use of jigs, templates or fixtures.

By the adoption of a jig, we may or may not have diminished the total value of effort required to make the hundred pieces. We have not *necessarily* diminished this total, therefore the use of a jig is not a matter of course; in many cases it is an economically unsound proposition. What we have to do is to conserve effort, but the only way we can measure effort in the economic sense is by money value. Before we can decide that the use of a jig will really conserve effort we must make a somewhat careful calculation. If such calculations are not usually made, that is because the data are not commonly at hand as they should be.

We have on one side the cost of making a jig, plus the cost of using it one hundred times. On the other we have the cost of applying the process, without the jig, also one hundred times. But this is by no means all. Other elements enter into the problem, which have an important bearing on its economic solution. Operation costs money quite apart from the labor concerned. Even a wholly automatic machine has a natural hourly rate just as a worker has a naturally hourly wage. A more complete consideration of the problem is the following:—

1. Cost of 100 pieces with jig:
    Materials of jig
    Labor on making jig
    * Machine time, ditto
    * Supplementary rate (expense)
        Total Cost of making jig ......
    Labor on 100 pieces, using jig
    * Machine time, ditto
    * Supplementary rate (expense)
        Cost of 100 pieces ......

    TOTAL COST OF 100 PIECES AND JIG ......

* It may seem that as we cannot speak of a machine as making an effort, the inclusion of these items is introducing some other element into the calculation. This

2. Cost of 100 pieces without jig:
   - Labor on 100 pieces ......
   - * Machine time, ditto ......
   - * Supplementary rate (expense) ......
   - TOTAL COST OF 100 PIECES, NO JIG ......

It is only when the first total is less than the second that the use of the jig is economically sound. This of course implies that the jig will not be required again. If more than 100 pieces are required, say 100 now and further lots of 100, then the probable number to be made during the whole life of the jig should be substituted for 100 in the first calculation. A scrutiny of this kind applied at least to all cases where jigs are of a costly nature would often prevent the locking up of money unreproductively. Few less satisfactory investments can be found than an assemblage of expensive masses of iron and brass, of which the future use is very uncertain.

The use of jigs has been considered somewhat more fully than space warrants because it demonstrates the viewpoint set up by the principle of conservation of effort. Conservation is the economic principle which is

is not so. Machine rents and supplementary rates are merely the cost of indirect effort of various kinds; each factor in them represents the cost of some service to operation. See the author's "Production Factors," 1910.

needed to supplement the principles of division and co-ordination before Effort can be said to be properly regulated. It is the chief merit of the "scientific management" and "efficiency" movements that they have brought this important principle into relief, the sphere of these movements being almost wholly directed towards promoting conservation of effort, more especially in this very department or function of design. But because of the lack of a precise analysis of the functions of management, and the laws of Effort, a great deal of confusion has arisen as to what the true sphere of these modern movements really is. It is generally supposed that their tendency is directly to increase the efficiency of Operation, but this is a mistake. No system of management can increase technical efficiency.

The confusion has been made greater by the accidental circumstance of Mr. Taylor's association with an important series of researches on the speed of cutting metals—a true type of *technical* research—but these researches have no more to do with Management than they have to do with Finance. They have obviously only to do with the technics of machine-shop operation and have no relation whatever to other industries, or to Management as a science.

What these new movements may properly be considered to say is this:—"In many industries there is great wastefulness of effort, and it is our endeavor to point out ways of reducing such waste. We do this, for the most part, by carefully considering and analyzing the way in which the available processes of Operation should be applied to the units of Product, *so that all effort not directly tending to produce by the shortest path* is eliminated. We find out this shortest path first, and then we proceed to specify it in great detail to the men concerned."

In some cases this work of eliminating wasted effort has been accompanied with a study of machines, that is with a real technical study of Operation.* But this has been successful only in those industries where machines are more or less "universal"—*i. e.,* can handle a wide range of work—such as machine tools. In many industries, however, there is absolutely no room for such

* For example, Mr. Carl Barth's "Slide Rules", intended to facilitate the "preparation" of machine tools for particular kinds of work. These are purely technical aids to a specific industry. They are inapplicable to other industries, such as shoemaking, chemical plants, foundry work and so forth.

studies since the speed of operation is strictly conditioned by unchangeable technical considerations. But in such industries there is still a large field for conserving effort in all the other functions.

When, therefore, any of these modern movements set out to eliminate Effort, and point out the shortest path for Production, they are really only applying the *existing* processes of operation *in the most direct way,* and they can only bring about this desirable result, at present, by minutely specifying in advance exactly how such processes are to be applied. The proof of this lies in the fact that they have not accomplished, and do not seek to accomplish, any general and improved methods of operation *which can be absorbed by the operative,* and thus become the foundation of new and better habit, and new and better tradition. All their energy is expended on individual items of product. Each such item must have its operation schedule in great detail.

But the specification of motions and times for individual items of product is obviously as much an act of design, as the specification of dimensions and limits is. In either case the instructions are confined to the individual piece; in either case they are specified in advance of the piece being made. The conclusion can hardly be avoided that conservation of effort in design is the principal field of activity of the modern movements.

Does it matter? It matters to this extent. It is a distinct gain to be able to set out on the path of trying to secure betterment with a clear view of the nature of the problem. If we have inefficiency on one hand and a vague and indeterminate doctrine of improvement on the other, it becomes a case of hit or miss whether we get any economic benefit or not in the long run. But if we can determine at the outset that our inefficiency is in Design, or in Control or in some other definite organic function, then we have only to scrutinize our application of the laws of Effort as regards that function to expose the cause of inefficiency.

The field of conservation of effort in design is a wide and important one. We have just seen how it may lead us, in some cases, to the substitution of lower-grade skill for high-grade skill when a number of identical pieces have to be made. This having been done where advisable, the next step is to determine the smallest amount of effort that will serve for the production of the piece. Here we enter the sphere of those methods of analysis called "Time study" and "Motion study". The whole object of either of these is to conserve effort.

Though such studies are sometimes carried out in the shops, they have no necessary connection with the function of Operation. In general it may be said that these studies are only properly carried out in the shop: (1) when units of product are so large that they can only be satisfactorily handled in the shop; (2) where new items of product are so infrequent that it would not pay to have a separate department equipped with the necessary machinery; (3) where, by the nature of the machinery, processes cannot be isolated for examination. In short, they should be carried out in the shop when it is either inconvenient or impossible to do otherwise.

It is not possible to enter on a detailed account of methods of time or motion study. We may note, however, that the object of motion study is to discover the fewest and shortest movements of the operator; and the object of time study to reduce these shortest efforts to time, and to record the time as a basis for subsequent operative remuneration. In some cases the question of rest-intervals enters into the question, and serves as a counter-element of a psychological nature, militating, not against conservation of Effort (for it is obviously one of the elements of this) but against operation in the shortest apparent time.

Having ascertained these particulars, they are embodied in specific Instructions or Schedules, which are as truly part of the complete design for any individual unit of product as the drawing is. In most cases, time required should be divided into (1) Preparation—*i. e.,* all preliminaries to actual production and all dismantling or clearing up after production; (2) actual operation on pieces.

Arising from the principle of conservation of Effort, another very important sub-principle—that of Standardization, or the principle of "fewest things"—needs consideration.

In setting out to manufacture a machine or mechanism it is obvious that a great deal of costly effort will be expended, and that this effort will be of various kinds. Our problem is then so to arrange the design that the resulting mechanism is produced with the very *least* effort. Strange as it may appear, there are many plants in which no searching, adequate examination of the product from this point of view is regularly made, particularly in those which are passing from the "making" to the "manufacturing" stage. On the other hand, there are plenty of industries where such preliminary examination of the product is, from the nature of things, very easy and obvious, and is never omitted. This is particularly the case where the initial stage is in the shape of a model instead of a design.

This preliminary scrutiny takes two directions. First, as to the simplicity and minimum diversity of parts. Are all the parts designed of simplest shape, having manufacture in view? Are all such things as screws, bolts, handles, levers, and similar accessories called for in the fewest sizes possible compatible with efficiency? Further, when several sizes or types of the product are to be manufactured simultaneously, we apply this scrutiny to the whole range of sizes. Have we worked out the designs with the fewest number of different sizes of parts, or components? This latter form of scrutiny is generally called "standardizing" the product, but the inquiry should go deeper than mere standardization; it should ask whether ultimate simplicity has been attained and the least effort wasted.

A writer once said, speaking of the trimness of German cities, that whenever a German laid a brick he looked round to consider its effect on the passerby. Similarly every draftsman who designs a component should have his eye on the way in which that component is to be made, with the means at his disposal in the plant he is working for.

Some of the means of securing this are almost childishly obvious, yet by no means universally adopted. Even in so simple a matter as specifying standard sizes of nuts and bolts in every case, instead of fancy sizes, many drafting rooms have no fixed rules. When it comes to utilizing standard parts already in use, boring a few standard sizes of holes instead of an infinite variety, keeping to stock patterns and sizes of accessories such as handles, levers, hand wheels, studs, etc., few plants consider the importance of such apparently petty savings.

Yet their influence in the shops is often something like the widening circles of a stone dropped into a pond. Multiplication of patterns, of castings, and especially of shop tools such as reamers, wrenches, drills and taps, unnecessary worry over ordering, issuing and storage, and whole waves of avoidable complication, are the result of not keeping the second division of Design in view all the time. There is nothing more expensive than a lack of clear thinking at the *beginning* of any series of operations.

Design is the most powerful influence for orderly progress, or for confused and aimless activity, according as its possibilities are utilized to the full or not. It must be understood, however, that it is not the capabilities of the designer so much as the traditions and practice of the plant that will determine the result. Where the principle of conservation of effort is fully understood, the natural tendency will be to proceed from the simple to the complex, and to the latter only so far as it is unavoidable. No one will then set himself to make drawings for a hand wheel, or a taper pin, until he has ascertained that no stock article will possibly do for the purpose.

Keeping down the number and variety of parts and of operations has an important bearing on cost of production. The more common parts there are, the larger numbers can be made at one time, the more familiar will everyone be with their manufacture, the more readily can they be fitted into a regular stream of production, and the steadier the stream of production the higher efficiency attainable in all departments.

Standardization, therefore, is a rather long name for a very simple idea. It may be conveniently summarized by describing it as the principle of "fewest things". These things are not merely the parts or units of the product, but also include all the accessories of a minor nature which are commonly purchased rather than made, and all the tools by which shop operation is carried out. To introduce an odd size of hole into a design means setting up a whole series of avoidable efforts, wasting time of a number of officials, causing running to and fro, and increasing the chances of error. It is a serious offence against the laws of effort.

A further application of the principle of conservation in design applies in some industries in regard to the specification of "finishes". Unlike "limits and fits", finishes have no relation to co-ordination; they imply no question of gap or overlap; but on the other hand they are often wasteful of effort. To spend time on careful surface finish where there is no economic call for such finish is simple waste, and therefore, in those industries to which it applies, specification of the exact degree of finish to be given is a recognizable part of Design.

Conservation of Effort in Equipment.—Conservation of Effort in relation to the arrangement of Equipment might be called the principle of the "shortest path". The daily transactions of a factory may be regarded as a perpetual ebb and flow of material, raw material flowing into the shops and surging up to the machines, and finished product returning from the shops. The importance of confining this movement to the shortest possible path is sufficiently obvious. But the path traced by product will be conditioned by the way in which Equipment has been installed.

When, therefore, the area required by each department has been worked out, the next task is to so arrange their relative positions that the least effort is called for in effecting the transfer of product between any two such areas. But this calls for an important qualification. It does not necessarily imply that the departments must be physically alongside each other in all cases. *The governing consideration is Effort, not distance.* Now it may be quite possible in many industries to convey product, mechanically, quite long distances with a trifling expenditure of effort. Industries in which, for example, it is possible to use band conveyors, shoots, or other automatic transporting mechanism, are in a different position from those in which the product consists of heavy castings that can only be handled by very expensive cranes.

The lay-out of Equipment is, therefore, by no means always and necessarily along the lines of providing the shortest *physical* path of travel for product. It should be on the lines of providing travel along the path of *least effort,* and as has just been pointed out, this may sometimes and quite conveniently prove to mean a path of considerable *physical* travel. To convey product 100 feet and up two stories may frequently mean less effort than to transfer it by other means across the shop.

While this qualifying factor must be pointed out, and indeed it is an exemplification of the value of getting right down to the fundamental principles of these matters, rather than being content with bald statements of practice, it remains true in many instances that the path of least effort and the shortest physical path coincide. For practical purposes we may therefore speak of the "shortest path", meaning in general the shortest physical path, and this principle will then apply to *product, persons* and *communications.*

In the installation of Equipment, therefore, conservation of effort means so laying out the plant that, after taking into consideration all the possible shortening of physical paths by means of conveying mechanism for the product, elevators for the persons, and automatic carriers or pneumatic tubes, telephones *etc.,* for the communications, the amount of Effort used up in effecting transport of all kinds will be at a minimum.

Equipment must not only be installed, it must also be run. Administratively, as we have seen, this means the dividing up of the department of Equipment into "services", such as power, heating, sanitation, maintenance and repair, *etc.* In all these services the principle of conservation of effort applies. Equipment services must be so planned that they are continuous and not spasmodic. In other words, forethought should be exercised so that the conditions for production, which it is the object of each service to maintain, should not be allowed to run down. The most important direction in which this applies is in regard to maintenance and repair. The proverb, "a stitch in time saves nine", should be the motto of these services, repairs being effected where possible *before* breakdown occurs and not after.

This implies that Equipment must be systematically inspected according to a regular schedule. Every item of Equipment should be scrutinized at definite intervals, and any signs of deterioration noted, so that arrangements may be made in advance to effect its repair at a time when the least disturbance to routine will be caused. When possible, the inspection service and the repair service should be in different hands, not only to get better control, but also to ensure that the inspection is regular and continuous.

Conservation of Effort in Control.—The Installation of Control involves planning spheres of duty, which as we have seen must be units of simplest skill and must cover the whole field without gap or overlap. These duties must also be considered quantitatively; that is, the amount of work involved in the performance of each duty, and the amount of time in which it can be done efficiently must be taken into account. It will sometimes be found, too, that although some particular task has been reduced to elements of simple skill and these elements fit together, the task itself can be conveniently dispensed with. In plain language, when we scrutinize duties in the light of conservation of effort, we may find that some of them are of the nature of "red tape". To these the pruning knife must be applied.

Each duty should be an *indispensable* link in the chain of Control. In arranging committees, for example, it is not sufficient to plan out the sphere of such committees,—say, for example, purchases, or production. Much more than this is necessary—they must be planned so that their labors conserve Effort, and not waste it. Men must not be withdrawn from routine duties at frequent intervals, to talk at random, and to wrangle and argue. Committees should meet at as wide intervals as possible, and for a specific purpose, with a specific programme or agenda on each occasion, to which all interchange of views should be confined. Such committees should, in fact, be regarded not as a Board wielding executive powers, but as a consultative gathering summoned by some superior official, who invites their views on definite particular subjects to be arranged beforehand. They should be similar in function to a council of war called by a general before taking some important step in a campaign; that is, to offer expert advice and not to make executive decisions.

Conservation in Control demands, then, that each effort should be considered quantitatively and in the light of whether it is worth while. It serves to eliminate red tape, and to make every effort of every worker contribute some absolutely indispensable quota to the general efficiency of Control.

Conservation of Effort in Comparison.— In the organic function of Comparison, the law of conservation of effort demands the shortest path from the unit facts to the final statistics. Here again we have to consider whether every stage of our process as mapped out is truly significant of some thing. In each stage we must ask ourselves "Why is this done?" And the answer in all cases should be that it is done because it cannot be avoided.

In practice, this principle of Conservation is frequently and persistently ignored. The introduction of mechanical appliances into accounting has not been an unmixed blessing, because too often the work has been fitted to the machine rather than the machine used as an aid to indispensable work. As a consequence, large and beautiful sheets of figures, full of detail, are prepared, though such detail is rarely or never consulted, and could be made available by other means if really wanted. In a properly graded system of Comparison, no fact should be recorded more than once, and the endless copying of facts should be eliminated remorselessly.

It must be remembered that the sphere of this function is Comparison and not Record. There is no use in recording anything unless at some future date it will be compared with some other record. Every figure put down on paper without this ultimate object in view is simply wasted, and this principle alone, if wisely applied, will often lead to the cutting out of much unnecessary figuring. To include such figures in statements is like showing the "working" of arithmetic sums, a matter of no practical importance, if the result is given correctly. And in accounting no result should depend for authority on its correct "working". It should always be capable of absolute proof by other figures.

It is a rare case, if, in a large plant, scrutiny does not disclose some unnecessary "returns". Often these have been called for by someone in authority, who had failed to get the information from the regular routine, perhaps because he had not familiarized himself with that routine. Then, possibly, he leaves or is moved elsewhere, but the compilation of the return goes merrily on—each official that sees it believing that some other official is using it. Conservation of effort in Comparison requires that all facts should be worked up, but that they should only be worked up once and the information they convey passed along the shortest path to those concerned.

Conservation of Effort in Operation.—Operation being the Function concerned with the technical processes of Production, and Production being the grand aim of any plant, it is evident that conservation of effort has a large and important field herein.

The sum of all the unit processes of Operation, machines, processes, and skills gives a "maximum capacity to produce", and the cost of this maximum capacity is in itself the sum of the separate costs of all the organic functions, including that of Operation itself. This is so important a point that it must be shown in tabular form.

COST OF MAXIMUM PRODUCTIVE CAPACITY OF A PLANT.

Cost of the Organic Function of:—	Cost of Maximum Productive Capacity, viz.:—
Design	Direct Labor Cost....
Equipment	Burden, as embodied in Machine Rents..
Control	Burden, as Embodied in Supplementary Rates ....
Comparison	
Operation	

N. B.—The two sides of this account must always balance.

If now we have a condition of affairs that does not permit us to employ all this productive capacity, it is evident that a waste of effort occurs. Where the "Production Factor"* method of factory accounting is in use, the supplementary rate forms an index of the

* See the author's "Production Factors," 1910; also "The Proper Distribution of the Expense Burden," second edition, 1913.

extent to which the maximum capacity is being actually utilized on work. If machines and production centers are fully employed, nearly all the burden will be absorbed by work through the machine rents, and the supplementary rate will be very small. As machines and other production centers (such as benches, assembly floors, *etc.*) become idle, the amount of burden absorbed through machine rents will decrease and that absorbed through supplementary rates will rise.

The first important lesson which is imparted by the law of conservation of effort as regards Operation is, therefore, the necessity of using productive capacity to the full. If all machines were to be idle for a single day, all of one day's capacity to produce would be wasted, but it would still have to be paid for. Moreover, productive capacity that is wasted is irrecoverable; it is gone for ever. On the other hand, if every machine is working on any day, conservation of effort *as regards productive capacity* is at its maximum, and nothing better is possible.

Twenty-four hour operation of machines would be desirable in all industries, as it is already imperative in some, were it not for the fact that it is less easy to apply the other laws of effort in such cases. Co-ordination of effort, in particular, becomes more difficult when three eight-hour shifts are worked. This is quite apart from the human factor which does not so readily lend itself to unusual hours of work, or night work, in those industries in which it is not customary. In proportion as an industry is complex, and the product is of a kind taking many hours to produce one piece, the difficulties arising from co-ordination under such circumstances tend to a maximum.

We have now to consider another aspect of the subject. While it is obviously desirable that machines shall be kept fully in operation during working hours, it is equally important that each hour's work shall represent maximum efficiency of technical operation. In some industries there is but little doubt about this, since each machine can only do one thing at one speed and in one way. The possibility of speeding up, in such cases, really rests on new technical *invention* and that is wholly outside the science of management. But in other cases machines are not specific, but general machines; that is, they can perform different work on different kinds of material at different speeds and in different times. Machine tools are good examples of this latter class. A milling machine, for instance, will do almost anything in the way of shaping material according to the cutter used and the way in which the tables and speeds are manipulated.

Conservation of effort in Operation demands that whatever is required to be done, shall be done in the most direct and rapid way, conserving effort to the fullest extent. In proportion as machines are "general" this becomes proportionately difficult to ensure. It is because some of the newer methods of management have gone hand in hand, in certain cases, with improvement in the technical operation of machine tools, that so much confusion has arisen on the subject, and that minute scheduling of every step and movement of the operator has come to be considered as inseparable from progress in production. But this has only been necessary, or even excusable, first from the general character of machine tools, and secondly, from the almost complete ignorance among "practical" men as to the working capacity of each type and size of machine tool.

In a large variety of industries (viz.—nearly all those in which the product is discrete, and does not consist of a continuous band, as in paper-making and some textile industries, or of liquids, as in some processes of soap making, brewing, sugar refining, *etc.*), Operation consists of two parts, namely, preparation or setting, in which the machine is made ready, adjusted, or provided with special fittings; and Operation proper, in which the Product is being actually cut, pressed, twisted, mixed, sewn, heated or woven. Of these two divisions the former is pure waste. As long as it is going on, the machine is being hindered from performing its prime purpose, viz., operation. Conservation demands, therefore, that study should be given to reducing preparation or setting time as much as possible.

Another application of the principle of conservation of effort has reference to the confining of operatives' duties to operation. This applies, not only to the rank and file, but to all concerned in operation, foremen and officials alike. Men engaged in technical processes of production should not be made into clerks, messengers or laborers. Any such use of them hinders production, though apparent saving is made simply because the time thus wasted is charged to Operation instead of being charged to the function it really belongs to, such as Control or Comparison. In many shops this is so far recognized that a man can summon messengers, *etc.*, by pressing conveniently arranged buttons, instead of having to stop his machine, and waste its time and his own in running about.

TABLE XI. APPLICATION OF THE SECOND LAW OF EFFORT (CONTINUED).

"Effort Must Be Economically Regulated"

(3) The Conservation of Effort

Application of the principle that "Effort must be Conserved" points out that there is a particular kind of wastefulness of effort in each organic function that must be guarded against.

Determination of the *amount* of effort in the unit of Product.

In Design. Effort can frequently be saved by designing jigs and fixtures, so that a low-grade skill suffices to do very precise work. When and where this can be done economically is a matter of simple calculation of cost, provided the minimum number of pieces likely to be required is known.

Standardization also follows from this principle. Varieties or sizes of parts, tools, and auxiliary appliances should not be multiplied unnecessarily. *This is the sub-principle of fewest things.* Work not necessary to efficiency should be eliminated. This implies the specification in advance of "finishes".

In Equipment. *Installation.* Conservation implies the arrangement of equipment in such a way that the travel of product is as continuous and direct as possible. After each function has been allotted a definite area, Conservation demands that such areas shall be arranged so that travel of products, persons, and communications is at a minimum. It involves particularly the use of conveying and transporting appliances wherever possible. Principle of shortest path.

In Control. *Installation.* Conservation of effort in allotment of duties means that no duty should be set up for which there is not an economic necessity. This means avoidance of red tape and system as far as possible. Principle of fewest staffs.

Administration, use of mechanical appliances.

In Comparison. Conservatism of effort in Comparison has to do with the elimination of returns that are not directly significant and valuable. Many concerns are weak in the accuracy of their unit facts, and over-organized in the vast tabular statements they prepare from them. Conservation demands the shortest path from the unit fact to the final statistics. To settle what groupings of unit facts can be made to yield direct and significant information requires expert experience of a high order, in all business of any size. Principle of least clerical work.

In Operation. Too much metal in jigs. Keeping technical men on technical work, not fetching or carrying. Keeping machines at work. Avoidance of clerical work by technical men.

We have now passed in review all the organic functions in the light of the principle that Effort must be conserved. We have now to consider the last sub-section of the second law of Effort, which, by declaring that remuneration is requisite for effort, leads us to search out, in regard to each organic function, just what types of effort are most significant of efficient conduct of that function, and therefore worthy of special reward.

(4) Effort Must Be Remunerated

A very brief description must be given of the working, or it would be more proper to say, the potential working of this principle, as regards most of the functions, because very little attempt has hitherto been made to provide special reward for so-called indirect workers. Most of the attention has been focused on the reward of Operation, although among the many queer vagaries of the school of "scientific management", there was published not long since an example of a schedule of janitor's duties minutely specified and sub-divided, with a bonus for each sub-division worked out in such desirable fragments as $.0075, $.1575 and so forth. Even in face of this it may still be said that the reward of duties other than those of operation proper is still undeveloped.

Some part of the responsibility for this undeveloped state of the subject is no doubt due to the fact that indirect expense is usually sensed as a vague and even an alarming factor in production. Its analysis into definite organic functions will, it is hoped, assist to remove some of the cloud of suspicion hanging over expense, by showing that its share in the total result, viz.,—Product, is just as definite, and its presence in due proportion just as necessary, as is operative labor itself. But on the other hand, it is just as important and just as necessary to render it highly efficient by proper reward as it is to do the same for direct labor. Perhaps even more so, for while the cost of the function of operation can be reduced in slack times by discharging men, the personnel of the other functions can only be reduced at serious inconvenience in many cases.

Remuneration of Effort in Design.—The history of special reward in the function of design is a very short one. It suggests the famous chapter "On Snakes" in the History of Ireland, which consisted of the simple words "There are no snakes in Ireland." Similarly it may be said that no general practice exists of rewarding Design on any other basis than that of straight salary. The reason for this is that there is practically no possible measure for the designing act. As has been well said by Mr. James Hartness*—"The ordinary work of machine design, in which well-known parts are grouped to accomplish a given end, without much thought of attaining anything approaching the best, —such designing is like painting a fence, so many square feet should be covered per day. But the real higher type of work cannot be measured in this way."

It is probable that the very nature of Design in its higher branches will render it as incapable of measurement in the future as it has proved to be in the past. This is because it is purely creative work, like the writing of a poem, or the painting of a picture. Considerable reward may follow on a new creation, or it may not, but in any case such reward generally bears but little relation to the amount of time, energy and effort expended. But while creative design must remain on a plane of its own, it does seem possible to introduce special reward into some of the more routine activities of the function of Design.

*"Human Factor in Works Management", p. 92.

In each of the organic functions we shall try to isolate that specific quality which lends significance to the duties of the function. Now in Design—that is, in the preparation of working drawings, specifications and instructions—there is one such specific quality very clearly indicated, viz.,—accuracy. Errors in such matters are about the most expensive class of mistakes that can be made in a plant, seeing that an error at this stage perpetuates itself in a whole series of wasted efforts on the part of other people. Further we have the principle of "fewest things", referred to in a former chapter, to consider. Contravention of this principle may be regarded as equivalent to an error in design—the specification of a dimensional relationship of an odd character, demanding tools not already in use, or of some accessory of an odd size, not already in stock, are errors akin in their consequences to a specification of the wrong material or the wrong size of a part.

Special reward may, therefore, be based on the freedom from errors possessed by the work of individual men. But this must not be supposed to be an easy matter. It will depend on just how far the general organization of the drafting room and of the system of Control is of a high order. The draftsman can only be held responsible if every kind of information necessary to him is immediately available. In few plants is this the case as yet. Attempts that have been made to introduce bonus or special reward into drafting rooms have not met with encouraging success, largely because success depends on factors beyond the control of the man concerned in many cases.

Remuneration of Effort in Equipment.—This applies wholly, of course, to the administrative aspect of Equipment, and not at all to its installation. The latter is paid for out of capital in most cases, and the only efficiency of remuneration possible in regard to it is keen buying.

The "services" into which the function of Equipment is divided (power, heating, lighting, sanitation, conveying, maintenance and repair, *etc.*), are, as has been pointed out, essentially concerned with the maintenance of *uniform conditions.* The uniform character of these conditions is therefore their specific feature. Keeping up steam pressure, temperature, cleanliness, *etc.,* and elimination of stoppages by breakdowns are classes of effort which would seem to be possible of special reward. To effect this, close inspection and record are necessary, but high efficiency cannot be secured without these in any case. With the clear delimitation of responsibility called for by the principle of coordination of Control, there seems no reason why the services of Equipment should not be standardized and made the subject of special reward. In connection with such services, the "bulletin-board" system of publishing such matters, making them an object of general interest to the employees as a body, could be usefully applied.

Remuneration of Effort in Control.—In the higher departments of Control, in which the grade of capacity concerned approaches the professional status, it is not likely that specific reward will ever be thought desirable. But in the lower branches, where such men as storekeepers, order clerks, routing men, *etc.*, deal entirely with routine matters, it would seem that some description of special reward will eventually be worked out. The routine duties of Control have two factors that condition their efficiency: (1) prompt handling and despatch of their work; (2) accuracy in such work. Errors, misunderstandings, delays and forgetfulness are the diseases of such routine duties, and their absence should therefore be promoted.

The keeping down of arrears in work to an irreducible minimum is a matter not difficult of ascertainment, and the fixing of a bonus dependent on the number of days per month on which work was entirely cleared up by each man in question does not offer any insuperable difficulty. As regards errors, these are more difficult to assess, because their consequences are not uniform. Some errors may be condoned because their results are trifling, but others may have serious consequences, and these are precisely what must be discouraged. It is possible that in any given plant, the different kinds of errors usually met with may be graded into three or four groups, and a definite loss of bonus assigned for each grade. The matter is one to be approached with caution, but there seems no reason why special reward would not work successfully in this function on these lines.

Premiums or prizes may also be offered for suggestions making for improvements in the system of control, such as in storekeeping, handling and transporting product, *etc.*

Remuneration of Effort in Comparison.—Much the same classes of specific qualities are to be selected for special reward in the case of Comparison. The two essential features of comparison and recording work are (1) that it should not be in arrears, (2) that it should be accurate. This applies alike to the inspecting and to the accounting divisions of the function. It should not therefore be difficult to work out a method of special reward for the officials concerned with comparison based on deductions of bonus for arrearage, and similar deductions for errors.

Special prizes may be offered for improvements in blanks or forms, or for pointing out defects in methods of collecting unit data at their source.

Remuneration of Effort in Operation.—The field of remuneration as regards Operation is such a large one and so much has of late been written about it that only the briefest mention is necessary here. In the appendix to this book, however, will be found an examination of some of the best known systems of premium and bonus in the light of their bearing on expense burden, and therefore on total cost.

Generally speaking the specific quality selected for remuneration in the shops is that of doing the most work in the least time. This implies, of course, that such work comes up to the standard of quality set by inspection. All bonus systems therefore demand a sufficient development of the function of Comparison, which includes inspection, and also the record of earnings. For the most part they also demand that the function of Design shall be developed to the extent that the standard time and the standard processes on each part are closely ascertained and specified in advance. In fact, to work bonus systems satisfactorily, a high degree of development in all the other four functions,—viz., Design, Equipment, Control and Comparison—is necessary. In other words, as has been pointed out several times, Conservation of Effort (or cutting down direct labor cost) is by no means the whole story in modern management. To be successful it should be the *final* stage in betterment, not the first, because the establishment of suitable conditions in all the other functions is necessary if permanence is to be secured.

The Second Law of Effort is tabulated on the following pages.

TABLE XII. APPLICATION OF THE SECOND LAW OF EFFORT (CONTINUED).

"Effort Must Be Economically Regulated"

(4) The Remuneration of Effort

Application of the principle that "Effort must be remunerated" discloses that there is, in each organic function, a special type of efficiency to be encouraged and rewarded.

In Design:—Relates to the basis of reward specially applicable to the work of Design. Bonus or other payment systems for routine work of drafting, tracing, coloring, printing, *etc.* Special premiums for exercise of inventive faculty. Rewards for simplification of design for manufacture. Special feature—Reward for improvements.

In Equipment:—Bonus systems based on uninterrupted service of belts, motors, power, *etc.* Rewards for detailed improvements in service or economy in service. Special feature—Reward for maintenance of uninterrupted favorable conditions.

In Control:—Bonus systems based on the absence of hitch due to errors, forgetfulness, misunderstandings, storekeeping errors. Special feature—Reward for smooth working, leading to absence of delays arising out of poor control.

In Comparison:—Bonus system based on promptness and accuracy—for keeping work up-to-date. Rewards for improvements in blanks, books and methods, and for pointing out defects of accuracy in method of collecting prime records, such as operatives' job time. Special feature—Rewards for accuracy and promptness—absence of errors and delays.

In Operation:—For doing the best work in the least time (ordinary remuneration of operative labor by bonus or piece work). Rewards for improvements of processes, machines or tools, and for reducing wastes. Bonus for supervisors, based on high earnings of bonus by their subordinates. Bonus for lowering percentage of waste, spoiled work, *etc.* Special feature—Reward for economical operation.

Chapter IX

APPLICATION OF THE THIRD LAW OF EFFORT

Sub-principles 1, 2, 3, and 4

1. Good physical conditions and environment must be maintained.
2. The vocation, task or duty should be analyzed to determine the special human faculty concerned.
3. Tests should be applied to ascertain in what degree candidates possess special faculty.
4. Habit should be formed on standardized bases, old or new.

SO far we have been dealing with persons in their aspect as officials fulfilling special duties. We have in fact treated the human factor in production merely as an abstraction—a passionless, perfect, malleable, plastic article to be labelled "Designer", "Operative", "Storekeeper", "Clerk", as might be found necessary for the immediate purpose in view. In other words we have not been considering men at all but only the possible actions of Man at large. In the present chapter we shall get away from this bloodless and abstract view, and shall consider the human factors of production in the light of the third law of Effort, viz.,—*that "Personal Effectiveness must be Promoted."*

Every properly constituted young man believes that supreme attainment in almost any line of human endeavor is within his grasp. His remaining years are spent, too often, in discovering his limitations, and in undergoing the painful process of disillusionment. While ambition is the most powerful lever of success, disappointed ambition, on the other hand, is frequently a deadly blight on the energies. As industry develops, particular types of mind, habit and character find certain directions closed to them, and certain other directions more open to them than to others. A man is not just a man, he is a particular and specialized combination of powers, faculties and weaknesses, and as civilization becomes more complex, the importance of recognizing this becomes more important both to the individual and to society at large.

The idea is expressed popularly by the saying that "a square peg must not be placed in a round hole". But in modern industry, we find an infinite series of sizes, both of pegs and of holes. The field of inquiry thus opened up is as yet hardly cultivated to any noteworthy extent, but the problem has at least been recognized and stated, and given the title of "Industrial Psychology". The pioneer worker in this new field is Professor Hugo Muensterberg of Harvard, whose work "Psychology and Industrial Efficiency" should be in the hands of every progressive student of the science of manufacturing management.

In exhibiting the scope of the third law of Effort, we cannot go very deeply into these matters, or do more than indicate briefly what class of problems comes under the law. The whole subject is so new that only its main outlines can be indicated.

Methods of Promoting Personal Effectiveness

If we regard the strictly practical task of getting the best value for a given pay-roll, it becomes evident that a study of human beings, as such, will be remunerative. If we have bad conditions and surroundings, there will surely be a money loss on that account, since a man, no less than a cabbage, requires favorable conditions for thriving. If we are expending money for mental or physical services, it will hardly be a paying proposition to impair the possible maximum of such services, either as regards quantity or quality, by neglecting to maintain the most suitable conditions within our power. The first sub-principle of the third law of Effort may therefore be stated as follows:—

(1) Good physical conditions and environment must be maintained

Though a good deal more attention is paid to this sub-principle than was the case twenty or thirty years ago, it is probable that the subject is only half explored at the present time. We have passed beyond the idea that a workshop is necessarily a dark, dirty, untidy and unwholesome place, encumbered with the accumulated dust, *débris* and waste of years. We have come to realize that it is not really good business to have death-traps conveniently scattered about in the shape of unguarded machinery and belts. We begin to understand that a close and fetid atmosphere is not a necessary concomitant of either office or shop. We have even begun to appreciate that noise and confusion are really inimical to the proper functioning of the human mind at its best. But we have not learned the lesson very thoroughly, or carried its teachings into any great degree of refinement, save in a few instances. We have hardly begun to do as much for systematically promoting favorable conditions for the human factor in industry as a scientific grower of crops under glass does for his grapes, tomatoes, or melons.

Why is this? The answer must be that the human organism has a hardier vitality than a vegetable, that it can exist and even work in a fashion, under conditions far removed from the best. Where the growing plant would perish and become a total financial loss, the human being remains in evidence, still breathing and moving, still working, still earning wages. And the short-sighted employer of the past, observing all this, never thought of asking whether, in point of fact, the wages earned under conditions of discomfort were producing as much as they would if the worker were made comfortable. He could always see the *cost* of providing good conditions — what he failed to see was the *net* result, or efficiency.

In adjusting physical conditions and surroundings to promote the best working environment, the need of a sense of proportion is obvious. In the reaction from the old-time conditions, a tendency to overdo, with the accompaniment of paternalism and fussiness, will sometimes be manifest. To provide baths, it is not necessary to construct them of marble; to enliven the atmosphere of the workshop we do not need stained-glass windows of costly design; to provide dining facilities we hardly require to imitate the tone of a Fifth Avenue restaurant. On the contrary, the prime and fundamental conditions which are favorable to the free working of the human organism are simple and not costly. Simplicity is not only less expensive but actually more efficient than over-refinement. What we should strive for is the removal of bad conditions that are obviously destructive of efficiency, not the elaboration of what we may consider are specially favorable conditions, because the result of such elaboration, in the present state of knowledge, is always uncertain.

Our aim should be to provide a generous minimum, rather than to undertake the task of endeavoring to raise the standards of the persons concerned beyond the level at which they may happen to be. Though this may be undertaken, in some instances, as a hobby or from some sense of duty, it cannot be regarded as strictly part of the science of industrial management. Much of what is known as "welfare" work, is therefore outside the limits of the third law of Effort, though at some future day it may be so well explored, and its utility so firmly established, as to become a recognized sub-principle of that law. At present it must be regarded either as philanthropy, or at best as an experimental attempt to extend the limit of application of the law. In very large factories, forming, as they sometimes do, quite considerable communities, perhaps isolated and self-contained, the administration may project its energies into the area of social life, at least to the extent of leading and guiding it. But such activity can hardly be said, at the present day, to form an inalienable part of the management of industries, if only because it is, for the most part, an entirely optional responsibility, and opinions are divided as to whether it ought to be assumed, or even whether it can be assumed with ultimate benefit to all parties concerned.

Our line of inquiry must therefore be towards establishing certain well-recognized minima of hindrances to the free working of the human organism. We must endeavor to find out what are the normal conditions under which the ordinary man finds himself at his best, and then take precautions to maintain his surroundings at this minimum level. Naturally, for different kinds of occupation, quite different standards of minimum conditions will be required. The weigher at the cupola will not require such a perfect equilibrium of conditions as the president in his office, or as the designer working on a new scheme. But neither the weigher nor the president can work in the dark; neither can work efficiently at zero temperature; neither can work twenty-four hours a day; neither can do his work properly if subject to constant interruption that distracts his attention. For each, in his respective degree, therefore, there will be a minimum of conditions below which his efficiency will suffer, and the object of the first sub-principle of the third law of Effort is to observe what these minimum conditions are, and to maintain them.

Most persons work at their best when they are unaware of their surroundings. They work less efficiently as their attention is diverted from the work in hand by unpleasant sensations. And this holds true, even though the marvelous faculty of "inhibiting" attention makes it possible to work under very bad conditions where these are habitual and customary. For recent scientific opinion tends to the belief that even though we succeed in inhibiting attention to a regular noise, for example, and do not in fact notice it, it has a disturbing effect on the organism all the same. Besides, the power of inhibition varies in different individuals, and it also varies according to the amount of concentration necessary for the work in hand. A mathematician, once immersed in his problem, is proverbially proof against earthquakes; a poet in the throes of composition has his nerves set on edge by the crinkling of a sheet of paper. These are, of course, extreme cases, but all intermediate stages may be found.

If, therefore, persons can accustom themselves to work under the most unfavorable conditions, it does not follow that it is good for them or their work. It may be taken as a thoroughly-proven principle that the better the conditions the better the work. This is particularly the case when bad conditions are intermittent. Starting to work, for example, in a cold shop at a temperature around freezing point is an example of conditions that make for much more inefficiency than is commonly believed. Working in failing day light is another such condition, as anyone can try for himself, and experience the relief felt when a powerful light is turned on. Yet frequently absorption in work inhibits attention to the insufficiency of light, though the strain on the faculties has been gradually augmenting all the time. It is only when this strain, and the feeling of discomfort to which it gives rise, overpowers the inhibition and calls our attention to the cause, that we perceive how far we have been incommoded by the bad conditions that have stolen upon us.

The whole subject of industrial psychology is fascinating, but it is also, at present, rather nebulous and vague. To keep our inquiry within practical limits, it will be well to confine our attention to the common experiences of factory life. Even when we do this the subject is full of dangers, because of the tendency to replace what should be fluid human relations by clumsily ascertained standards. The moment we fix certain standards of conduct, attainment or merit, we set in motion a whole chain of dissimulations. Men give their attention, not alone to doing well, but to the appearance of doing well according to the arbitrary standards they find set up against them, and they are apt to develop a great deal of ingenuity in doing this. Elemental simplicity in making arrangements to guide human nature is therefore essential to success.

We may begin by a study of physical necessities. Fresh air, warmth, good light, quiet, movement free from danger are conditions desirable for any kind of work. But merely stating this is not enough. All these factors require stating in more precise terms for different purposes. Fresh air should not imply drafts. Warmth should mean definite limits of the thermometer. Light should be considered not only with regard to quantity, but with regard to the angle at which it strikes the work, to the shadows it produces, and the presence or absence of glare. Quiet is a relative term; very different degrees of quiet are essential for a molding floor and an accountant's office. Freedom of movement is also relative; movement is safer in the offices than in the shops, from the nature of things. But no obvious danger should be permitted to exist that can be guarded against. Men will move more quickly where they can move safely, even though familiarity with danger produces callousness.

These more obvious physical conditions being attended to, we come next to indirect conditions. It is becoming appreciated that sanitary, clean, and bright surroundings have an influence on the spirits. Shops that are clean, bright and orderly will not only attract a better type of man, but will also exert an unconscious influence on everyone. Human nature is so sensitive and ready to adapt itself to its environment that a careful man working in a dirty and disorderly shop will lose some of his best qualities. Similarly, an untidy go-as-you-please kind of man coming into a shop which is scrupulously clean and bright, and where nothing is out of its place, will unconsciously feel the influence that such orderliness exerts, and will begin to improve.

The primitive wants of men should be carefully provided for. Sanitary appliances, latrines, washing facilities, clothes lockers, should not only be provided but maintained in an orderly condition. They should not be placed in any odd corner, but so distributed as to avoid congestion and crowding. Further, the supply of drinking water should be carefully attended to. No one should have to go far for a drink, and the accommodation provided should be such as a self-respecting man cares to use. In many cases this important matter is neglected. It is one of those small points that silently make for efficiency.

Next we come to what may be termed the "protective" services. Foremost amongst these is the fire service. Every factory of more than one story, and all buildings of one story in which there is anything to burn, should be provided with a sprinkler system. In addition to this, fire drill should be rigorously insisted on. Fire wardens should be appointed and held responsible for seeing that emergency doors, stairways and gangways are never encumbered, that doors are always unlocked during working hours, and that alarm apparatus is tested at frequent, regular intervals. The most elaborate precautions sometimes fail, with terrible results, for want of efficient inspection.

The fencing of all dangerous machinery, and of elevator shafts and similar openings in floors is not merely dictated by common humanity, but is actually the cheapest kind of investment. Movement surrounded by dangers will always be slow and cautious movement, even though it becomes an unconscious habit after a while. Unfenced dangers are a handicap which it is very easy, and not at all costly, to remove, and in many States, as in most foreign countries, the Law has stepped in to force these obvious precautions on careless employers. It is certainly a case where force is applied for the employer's own good, however blind he may be to the fact.

In all factories not situated in the midst of towns, the organization of first-aid to the injured should be one of the protective services to be provided. In larger plants, this may usefully be developed into a regular medical service, with or without hospital accommodation for emergency cases. The question of sick and benefit funds, and of workmen's compensation for accident is also an important one in large plants, but in the United States as in most industrial countries in Europe, it is passing out of the control of the private employer into the larger, if not more capable, hands of the State. It would seem to be only a matter of time before insurance of every kind will be as compulsory on every citizen as is the payment of taxes. Already in some European countries industrial insurance against sickness, accident and even unemployment is compulsory, and the community undertakes to look after the declining years of its poorer citizens by means of old-age pensions. It does not come within our province to offer any comments on this tendency, since universal application by law removes such questions from the domain of the science of management, which has then no field for discussion nor any option but to apply them.

Under the head of accessory conveniences we may enumerate the provision of meal rooms, with or without kitchens attached; bath facilities where the nature of the work seems to call for them; rest rooms, and so forth. Of these the meal room is perhaps the most important feature where employes come long distances to work. They cost little unless space is at a premium, and especially if provided with some simple conveniences for heating food brought ready prepared by the men, make a distinct place for themselves as promoting effectiveness of the employee.

A matter to be wisely guarded against is the introduction of fussy rules as to smoking and minor personal habits. Such rules are well meant, but are apt to be regarded as unwarrantable interference with personal liberty, as it must be confessed they are. Grown men should be treated as such, not as creatures of undeveloped intelligence. Outside the shops men should be left to themselves as far as is consistent with the maintenance of elementary order and decency of conduct.

We have now enumerated some of the more important points to be considered in regard to the physical welfare of the human factor in production. To elaborate them in detail would require a volume devoted to the subject. Some of the points mentioned are more neglected than many owners of factories are themselves aware, because they are precisely the kind of arrangements whose efficiency is taken for granted on the one hand, and apt to be undervalued on the other. But the importance to old-established concerns lies in the fact that modern plants are giving attention to just these very matters, and where old and new are in competition they may have considerable influence on the obtaining and keeping of the best class of help.

Vocational Fitness.

The next division of the third law of Effort to claim our attention is of a totally different and much more difficult and debatable character. It is also by far the youngest and least developed branch of the subject, having only begun to assume importance within the last few years. It is the special field of the new science of "Industrial Psychology" already mentioned. It may be briefly described as the study of "Vocational Fitness"—"the selection of those personalities which by their mental qualities are especially fit for a particular kind of economic work."

Actually the study of vocational fitness gives rise to two sub-principles of the third law of Effort, which, for convenience, and in consideration of the novelty of the subject, will be treated together. These two sub-principles are:—

(2) Every vocation (occupation, task or duty) calls for special and definite human faculties.

(3) Every human being has certain faculties more developed and developable than other faculties.

As they stand here these two sentences are merely statements of fact. We can now translate them into the mandatory form in which most of our principles have found expression, as follows:—

(2) The vocation, task or duty should be analyzed to determine the special human faculty concerned.

(3) Tests should be applied to ascertain in what degree candidates possess special faculty.

It must be insisted at the outset that this new branch of the science of Management is as yet almost unbroken ground. The necessity for caution in the matter has been emphasized by Professor Muensterberg himself:—

A word of warning may be given beforehand so as to avoid misunderstandings. These examples do not stand here as reports of completed investigations, the results of which ought to be accepted as conclusive parts of the new psychotechnical science; they are not presented as if the results were to be recommended like a well-tested machine for practical purposes. Such really completed investigations do not as yet exist in this field. All that can be offered is modest pioneer work.*

This warning is needful especially if, as seems likely, we are to be over-run with a new swarm of "experts", professing to de-

*"Psychology and Industrial Efficiency," page 61.

termine vocational fitness for employers at short notice, because it may fairly be assumed that there is but little justification for such claims at the present time.

MOTION STUDY NOT A PSYCHOLOGICAL ANALYSIS.

The difference between this psychological analysis and that performed by time or motion study should be clearly understood. The sphere of motion study is to determine the path and sequence of physical movements, and the normal time that should be occupied in the performance of each such movement. It is therefore an investigation into method, not an investigation into faculty. Motion study, by reducing operations to their prime and necessary elements, is enabled to combine these elements in the shortest way, with the least expenditure of effort, and therefore in the shortest time. But it does not measure the fitness of this or that man for the particular combination of motions that it has found to be the best. Its only relation to the study of vocational fitness is by way of observing that some men take longer than others to go through the same series of motions. But it does not attempt to throw light on the very important question WHY some men are more adapted to the particular work than others.

It is precisely at this point that the new science of industrial psychology, or psychotechnics, enters the field. It may be well to approach the subject from the most elementary point of view. We may take the simple and well-known cases of railroad engineers or ships' officers, with whom a prime necessity of their calling is that they should be able to distinguish between red lights and green lights. However fit in other respects a man may be for either of these vocations, unless he possesses a normal sense of color he is barred from them. The important point is, of course, that such a man is usually quite unaware that other people see green and red light differently from himself. Until a correct test is formulated and applied, such men would readily undertake either of these vocations in all innocence of their entire unsuitability for them.

The case of color blindness is a very simple and elementary one, first because the faculty in question (that of seeing green and red as normal people do) is clearly defined and marked off, and secondly because the test to be applied is easily formulated. But as we shall see later, the difficulty begins when we have not only to formulate tests, but first to discover and delimit what faculty it is that we are to isolate and give preference to.

The selection of the instance of color blindness must not be taken to suggest that the sphere of industrial psychology is wholly one of elimination of the unfit. In this particular instance it is so, because it happens that color-blind persons are only a small percentage of the total population. On the contrary the real objective of the new science is selection rather than elimination. Its purpose is not to throw the square pegs out of the round holes, but to gently shepherd the round pegs towards the round holes, and the square pegs towards the square holes. In the beginning of its application, however, it will be largely eliminative because its opportunities are confined at present to studying particular vocations, and eliminating those unfit for them. Later it will probably find an opening in the study of the individual and will point out to him which of a wide range of vocations he is likely to succeed in. This, however, obviously cannot come to pass until a large number of vocations have been studied by *competent* psychologists.

Illustrations of the Method.

Professor Muensterberg's investigation into the causes of street car collisions is an interesting example of the method. The problem was (1) what particular kind of faculty is concerned in mentally seizing on and responding to movements in traffic crossing the tracks in time to prevent collision, and (2) how could the presence or absence of this faculty be detected in candidates. Professor Muensterberg says:—

> I found this to be a particularly complicated act of attention by which the manifoldness of objects,—the pedestrians, carriages, and automobiles,—are continuously observed with reference to their rapidity and direction in the quickly changing panorama of the street. . . . In the face of such manifoldness there are men whose impulses are almost inhibited and who instinctively desire to wait for the movement of the *nearest* objects; they would evidently be unfit for the service as they would drive the electric car far too slowly. Then there are others who, even with the car at high speed, can adjust themselves for a time to the complex moving situation, *but whose attention soon lapses*, and while they are fixating a rather distant carriage, may overlook a pedestrian who carelessly crosses the track immediately in front of their car. . . . My effort was to transplant this activity of the motormen into laboratory processes.*

* Psychology and Industrial Efficiency, Chapter VIII.

To accomplish this the task was not to reproduce "external similarity of the apparatus, but inner similarity of the mental attitude". After some experimenting, the device of a window moving over a card marked with heavy double lines representing a track, and movable at any desired speed by the candidate, was adopted. On the card were figures in red and black, representing items of traffic moving at different speeds, both parallel and across tracks, and the test was for the candidate to move the window as rapidly as his mental grasp permitted and call out the distances at which the different items of traffic would reach the track.

Before attempting to apply this test to actual candidates, two demands had to be satisfied, and these could only be ascertained experimentally. First, it was necessary to find whether the method of testing did actually show good results with motormen of known reliability and bad results with inefficient motormen; and secondly whether it aroused vividly in all the motormen the feeling that the mental exercise they were going through was similar to their experience on the platform of a car. Not until these two proofs were forthcoming, and the genuine character of the test thus proven, was it applied in practice.

Professor Muensterberg's inquiry into the mental qualifications necessary for telephone girls have been so widely described that it is not necessary to include them here, further than to recall that in addition to special factors, a "general intelligence factor" was tested for and made a part of the examination. This is worthy of notice, not only because some psychologists deny the existence of such a factor, but as showing the exceedingly subtle and difficult nature of any inquiry into human faculty. The allotment of "points" or "marks" for success in each of a series of tests must always be of an arbitrary character, though conceivably it may be practically valuable. The human being, moreover, is not the same at one time as at another. At one time a person is "full of life" and at another time is sluggish and slow. At one moment the attention wanders, and at others it is easily concentrated. It is inconceivable that the same series of tests applied under these circumstances at different times to the same individual would not have different results, and result in a different grading.

Industrial psychology is therefore no field for the amateur to dabble in, especially in view of the grave injustice that may be done to employes or prospective employes by crude and faulty application of such methods. Nevertheless, it does not seem impossible that some simple and broad groupings of faculties can be made and tests devised for them, so that obviously unsuitable persons shall be excluded from positions they would be unable to fill, and on the other hand that certain faculties shall be recognized as present to a considerable degree in certain men, with a view to making use of such faculties when the question of promotion is up.

The higher the post the more difficult it will be to dogmatize as to what a given person will or will not do, if he is permitted to fill the post. There is even great danger in endeavoring to stereotype the qualifications demanded for the higher posts. The danger is, of course, that a new departure in the direction of progress may result from the incursion of a new type of mentality into a given field of action. Every individual's success is a net balance between his qualities that do make for success and those which do not make for success. No one is all good qualities, or all bad ones. It is only the preponderance which counts. And the higher the type of activity the more impossible does it become to say, or even guess, at, what the net result might turn out to be.

In lower posts, certain simple psychological tests might be possible. Some posts require a good memory, others quick decision, or selection of alternatives, others again demand a sturdy independence of character which will not yield to cajolery or descend to petty ''graft''. Some positions demand suavity, others inflexibility as their predominant feature. Of course all this is nothing new. Men have always been selected with an eye on their outstanding qualities as far as these could be seen. The new departure is the proposal to assist the judgment—that is the instinctive judgment of the ordinary man—by some more definite instrument of analysis, some *quantitative* instrument of analysis, so that more definite judgments are possible.

The whole subject, however, is so new and undeveloped that employers need rather to be warned against possible extravagances than encouraged to rush into the field. At the same time there is certainly the germ of great future development in the idea, and therefore it must take its place as one of the sub-principles relating to the promotion of personal effectiveness.

Habit

We enter a much less debatable field when we consider the influence of correctly acquired habit on the various officials and workers in an industrial plant. Nevertheless, under the influence of the new methods of analysis, particularly time study and motion study, that have been so largely employed and talked about of late years, the enormous value of habit as an element of industrial stability has been lost sight of to some extent. When industrial habits and customs are all under scrutiny and criticism, and many of them found to be unwarrantable, it is natural that the real place and significance of habit should be somewhat forgotten.

In speaking of habit it must be remembered here that we are not concerned with ethics, but with administration. We have nothing to do with the personal habits of men, whether they drink or smoke, whether they play cards or billiards, whether they are meat eaters or vegetarians. Still less have we to concern ourselves with their mental habits outside of industry. We must not inquire their attitude towards woman suffrage, or anti-vivisection, or whether they are church members, or whether they are spendthrifts or savers. Those are the private habits for which each citizen is responsible only to his own conscience, and it is invading his rights as a citizen to pretend to control them or even to inquire into them. Even if we persuade ourselves that such and such habits in private life tend to make a man a more satisfactory member of an industrial organization, we must be content to abide by the actual record of the man in his industrial capacity, and not carry our zeal so far as to invade his private life. Nothing is more fraught with danger to industrial peace than a spirit of meddlesomeness with matters that are no real concern of the employer. He is not his employees' keeper—indeed he has a sufficiently large task if he confines his horizon to the actions of the employee in his industrial capacity.

With this important reservation as to the meaning of the word habit we may define the fourth sub-principle of the third Law of Effort as follows:—

(4) Habit should be formed on standardized bases, old or new

and as habit has not one but many aspects, it may be as well to consider these in some detail.

It has been almost entirely overlooked that the importance of the revelations made by time study and motion study into operative methods, and the discovery of great inefficiencies in the application of labor to work, is mainly in the substitution of better habit for that which has been declared faulty. Firm progress can only be assured by taking the new revelations and transforming them into new habit. Some authorities seem to imagine, for instance, that there is a positive virtue in "written instructions" which the worker is expected to consult every time he performs the work. The obvious truth is, of course, just the opposite of this. Written instructions are simply an unavoidable nuisance in those industries which, having just been exposed to the critical artillery of motion study, have been found to be all wrong in their operative habit. They are unavoidable because, until new habit has been acquired, it is necessary to have at hand an authoritative statement of what is considered proper habit, but to regard them as an end in themselves, as many persons appear to do, is mere fetish-worship. The more often a given task is repeated the less necessity for "written instructions", until a time comes when to maintain them would be simple foolishness. In the complex operations of the machine shop, where the instructions of design are not really complete until they have specified not only the work itself but the accessory tools, jigs, fixtures and attachments with which it is to be done, written instructions are, of course, inseparable from the piece—as inseparable as the drawing itself, but in few other industries is there much excuse for attempting to train men in that way.

The valuable idea underlying "written instructions" is of course the standardization of methods. But this again is nothing but a long word for "proper habit". Now Mr. H. L. Gantt, who has been very successful in increasing the efficiency of textile workers, so far from being able to make use of "written instructions" in forming new and better habit in them, has achieved some of his greatest successes among men and women who were not only unable to follow written instructions, but were not even able to speak English. They learnt to follow motions and not words.

The first line of approach to the formation of a correct industrial habit is, then, correct operative habit, and this applies not only to the men in the shops, but equally to the members of all the other organic functions. Though less studied as yet, it will be obvious that all clerical workers should be encouraged to form good habit in carrying out the steps of their work. "A place for everything and everything in its place" is, for example, one of those homely adages that have a practical bearing on clerical as on all other work. The order in which the daily routine is carried out has often a considerable influence on success. In other words a certain amount of time and motion study, even though of an elementary character will be found useful in establishing good habit among the rank and file of employees outside of the operative function.

Industrial value is, however, not confined to the ability to go through a series of motions in a given time, however good a productive habit is created thereby. Skill and ability are no doubt prime factors, but steadiness, punctuality and long service are also factors that should have weight in determining a man's value to the organization. It is to be feared that in the zealous application of the new methods of analysis to plants, too much attention has been concentrated on the pure skill factor and not enough on these other factors, by which means valuable organizations have been more or less disrupted, and the gain made in one direction lost in another.

Some of the most pointed observations yet made on this subject will be found in Mr. James Hartness' little book already referred to;* and his remarks on the necessity for controlling ''progressive energy'', and his insistence on moving the worker along ''habit lines'' should be read by everyone interested in practical management. As Mr. Hartness truly says there is an ''Inertia of Habit'' which is as much a law of human nature as it is of engineering. This being the case it is evident that whatever habit exists throughout an organization can only slowly be changed for the better. Similarly, if through a long term of years an organization has been built up, resulting in a steady,

*''Human Factor in Works Management,'' Chapter II.

more or less contented, and faithful body of employees, the industrial habit therein contained has a very large economic value. To rush in and change all these relations and disturb all this habit in the name of Progress or of Efficiency is to do a very bad service to the organization. Even though analysis should reveal that everything that can be done badly is being done badly, there is still the asset of organic solidarity that remains, and this should be preserved at all hazards. *"Festina Lente",* "Hasten Slowly", should be the motto of every one who undertakes to introduce "betterment" into an established plant.

The relation between this aspect of habit and "standardized methods" may not be very clear to those that connect the latter phrase with something new and perhaps revolutionary. Standardized methods are not necessarily new methods. Of course a standardized method is any method that is recognized as too good to be altered, or as the best that can be attained or expected. Among these the habit of punctuality is certainly a standardized method—a regular compliance with the standard of attendance set up by the firm. Steadiness and reliability are also compliances with standards, even though unwritten standards. Long service may or may not be, just as the firm consider it a merit or not. But it certainly should be so regarded, and we may regard life-long service as the standard to which every employe is getting nearer as the years pass.

Thus we are able to observe the desirability of fostering good habit in all these directions, remembering always that habit has, as Mr. Hartness says, *inertia,* and can therefore be changed only slowly. The subject is capable of much greater development than has been made here, but its most important features have been mentioned.

Chapter X

PRACTICAL APPLICATION OF THE THIRD LAW OF EFFORT (*Continued*)

ESPRIT DE CORPS

THOUGH the phrase *esprit de corps* is sometimes translated by "team work," this is not an exact equivalent, yet perhaps the nearest approach that the English language allows. It omits, however, a very important shade of meaning, namely the feeling of pride in the group—originally in the corps or regiment—of which the members form part. The Cornishman's motto "Each for all and all for each" has also something of this spirit, though on a lower plane of thought. Generally speaking it may be said to include the American conception of team work *plus* pride of organization, implying though not expressing a superiority to the outside mortals not fortunate enough to belong to it.

In some industrial concerns *esprit de corps* is strongly developed. The "Company" is personified and made an object of regard and even of reverence. Where this feeling exists it has very great economic value. It is usually evidence of the passage or the presence of some strong and kindly personality whose influence has permeated the organization, and tinged it, so to speak, with a robust form of sentiment. But in other cases this desirable spirit is wholly absent.

The value of *esprit de corps* is so great (though in a world of change it is apt to be undervalued if not overlooked) that it must be regarded as one of the main engines for the promotion of personal effectiveness. For this reason we may include it under the Third Law of Effort, as forming the fifth subprinciple of that law:—

5. Esprit de corps must be fostered.

It may be confessed, however, that it is far more easy to lay down this principle, however obviously true it may be, than to state how the thing is to be done. For *esprit de corps* is so much the outcome of personality—the personality of the man or men at the head, that it is too elusive to be reduced to words, or rules. Nevertheless, we may turn over the subject so as to see what it is that should be aimed at. The possibility of developing it is based on a peculiarity of human nature. Humanity being gregarious —that is, having an instinct to associate in groups—it follows naturally that each of us has a tendency to declare and even to believe that our own group is a mighty superior kind of group. The accident of our being born in an Anglo-Saxon country gives many a kind of pity for the benighted peoples not so born. The Christian is sorry for the Brahmin and the Brahmin looks down on the Mahommedan. The inhabitant of a metropolis always has a kind of condescension for the provincial; the men of certain regiments in most countries believe that their regiment alone is the true fighting force of the State; to belong to certain clubs is considered as an immensely more valuable privilege than to belong to certain other clubs; in short, the whole world is divided into groups, each of which looks upon other similar groups with a calm superiority, that in four cases out of five has very little foundation in reason.

But though under the cold light of reason this group-pride has frequently little foundation in fact, it has nevertheless great moral force. It generates energy, both aggressive and resistive. The man who believes in his group will make sacrifices for its welfare. He will be ready to maintain its superiority against all comers. And he will be ready and anxious to identify himself with its inner life and amalgamate himself as thoroughly as possible with its traditions and customs. In Chapter VI of his book, Mr. Hartness speaks of "Confidence . . . born of a knowledge of the *superiority of existing things*—things that may not be perfect but are nevertheless best". This is in fact a fairly good definition of the condition of mind produced by a lively sense of *esprit de corps*.

Can we picture to ourselves any of the conditions that give rise to this state of mind? To a limited extent we can. A man finding himself in the position of a unit in a large group, such as a manufacturing plant, will tend to form *esprit de corps* if he finds around him an atmosphere of justice and fair-play, of leadership in which he can confide, of recognition of his efforts (not necessarily or always monetary recognition), of decent conditions under which he can retain and augment his self-respect. All these personal influences are necessary, without doubt, yet there must be something more than this.

An essential feature is *belief in the purpose for which the group exists.* In industry this means belief in the product itself and in the public recognition of its value. If a man works in the dark, without perceiving the end and aim of his labors, he is not likely to develop a lively sense of *esprit de corps.* But open up to him some of the excitement of propaganda, let him share in imagination in the work of the organization as a whole, and his interest is sure to be both widened and intensified. Let him feel that he is one of the players in the great game, and he will be much more inclined to do all he can to help the game forward, even though his personal share in it is a small and unimportant one. To him it will soon seem neither small nor unimportant, because it is a principle of human nature to magnify one's own place in the world and to believe that our position, our work, are pivotal matters, round which the universe revolves. To neglect the fostering of this excellent and happy frame of mind is to throw away great assets.

Just how, in practical affairs, this is to be effected, is, of course, a somewhat difficult problem, needing careful consideration in each case. But the broad outlines are clear enough. Every industrial group is in effect an army marching to the conquest of the world. Its battlefields are the offices of its customers. It has its territory already occupied in force, its territories in which the flag is only shown, its territories undergoing survey, its territories as yet wholly beyond its sphere of operations. It has its days of triumph, when large and satisfactory orders are secured. It has also periods of struggle and difficulties, when the army must march in close order with carefully guarded flanks—the days of industrial depression, when the question is not so much to make fresh conquests, but to keep what one has.

Some few firms have begun to use this array of stimulating facts to promote *esprit de corps,* at least among their sales force, but where it is really wanted is among the whole body of employees. In a large plant a new kind of publicity service seems needed, not to impress the imaginations of the world outside, but to develop the interest of the world inside the factory gates.

Suppose for instance some machinery has been shipped to a mine in South America, and that photographs have been secured of its passage on mule-back across some Andean pass, or across some turbulent river, and its arrival at its destination in some wild end of the world. Would not the exhibition of these pictures profoundly interest the men who had made that machinery, who had watched it being made—who had written the orders for its making, who had handed out the materials for its making? Nothing more so, yet how often is it done?

Or suppose a product that is fighting its way, from city to city, from county to county, from State to State, from the home to the foreign markets. Is it possible that a great map, on which the successive stages of this progress were shown graphically, would have no interest to the men who were devoting their lives to making that product? The passengers on an ocean liner find interest in the day's run of the ship, though they have no share in bringing about the result. Is it not likely that men would follow with still keener interest the fortunes of a product that they themselves help to make, and on which all their prosperity is dependent?

Synthesis, as was pointed out in a preceding chapter, is the great instrument by the skilful use of which the management will ultimately have to stand or fall. Now *esprit de corps* is the perfect synthesis of the good-will of individuals. It is the most important thing of all to secure and the most difficult thing of all to secure. It is a strong moral force, tending to polarize the wills of men in one direction, namely that of furthering the efforts of the group. But because it is a moral force, it cannot be brought about by mechanism alone. It is an outcome of personality in essence, and no system of management, no rules, no cut and dried principles, can supply the place of a fine personality at the head of affairs. And this brings us to another important matter—the difference between *esprit de corps* and enthusiasm.

When many people speak of enthusiasm as a fine force in business, they are really meaning *esprit de corps.* Enthusiasm is not a workable proposition, because it is not a steady enduring force. It is up and down, a kind of mental revivalism that is evanescent. Enthusiasm is an excellent thing in a crisis, but if we rely on it as a working force, we shall have confusion before long, because it is a *conscious* exercise of the imagination and the will, and cannot be kept up. The man who is naturally enthusiastic is nearly always unstable and unreliable. His mind is apt to run up side roads, to be diverted hither and thither. Much of the scrappiness of modern life is due to the fact that things are done under waves of enthusiasm—that is, of necessity badly, because hastily.

Esprit de corps should generate enthusiasm when the need exists for it. Soldiers cheer when making a charge, but they do not spend their lives in cheering. The salesman should feel enthusiasm when face-to-face with his competitors, or with some intractable purchaser, but calm consciousness of "the superiority of existing things" should be his normal state of mind. Similarly, when we speak of the essence of *esprit de corps* being personality, we do not mean that the man at the head of affairs should be, in the language of the Salvation Army "always on the mountains", that is, always under the stress of enthusiasm. On the contrary, the less of that quality he has in his make-up the more his chances for success. What he wants is calm but intense belief in himself, in his mission, in his men, in the power, strength of purpose, and justification of aim of his organization.

Within the plant itself there is also the opportunity for developing local *esprit de corps.* Each of the organic functions forms a group sufficiently distinct from the other groups to feel a common consciousness. The Designing group, the Equipment group, have for example a wholly different outlook, and indeed a different mentality, from the Operating group or the Comparison group. How can this essential difference of mental outlook be used to develop *esprit de corps* within the function? Of course, when any of these functions is only slightly developed in a plant, such as the designing function in a chemical industry, nothing in that way can be done. But where the functions are developed so that many men are employed in each, then something may be attempted.

The idea to be kept in mind is that of generating interest in the common daily happenings of the plant, and particularly of the function itself. There is nothing more highflown than this required. In a sense it is what may be termed the scientific use of gossip, or rather of the ineradicable tendency of mankind to gossip. Where everything in a plant is held down under a heavy weight of strenuousness, very little is accomplished. ''Stone walls do not a prison make, nor iron bars a cage'', is as adapted to an industrial organization as to a jail. We can control the body to some extent, but we cannot coerce the mind. If our work is uninteresting, the mind will wander away in spite of us to tomorrow's or last week's ball game, to the book we are reading at home, to a dozen other things not very pertinent to the work in hand. It will not wander the less if we are but a small wheel in a big machine, with no very clear or lucid idea of the exact utility of the work we are doing to earn our living.

The problem of local *esprit de corps* is therefore to give current daily interest to each man's work, to provide food for his errant thoughts, for his imagination, so that he will not look on his life within the office or shop as drudgery to which his noble spirit stoops, indeed, but unwillingly. Make him a world to live in within the organization, and his thoughts will not so readily fly to the greater world without. Local *esprit de corps,* that is, within each function, is so narrow a field, even in a large plant, that most of the influences that can be brought to bear must be considered presently under the head of Incentive. But the point here is that each function is a little world of itself, with common interests and needs, and that something can perhaps be done to make these interests appreciated by everyone, and make everyone anxious to promote them, not for personal ends but for the sake of *esprit de corps*.

A concrete example may be taken in the case of the power service. The efficiency of the power service depends on many factors and the co-operation of many individuals. There are standards to be maintained, and definite results to be gotten. In other words we have here an example of a local group in which the fostering of *esprit de corps* may be assisted by suitable arrangements. It will be remembered that we have defined one of the necessities of the situation as belief in the purpose for which the group exists. This being established we must connect the work of the individual with the realization of the purpose, and assist him to see the importance of his own share in the result.

Now the purpose or purposes for which the group exists is clearly definable in this case. It is to generate power and attain a certain efficiency in doing so. It may be also to keep up pressures or temperatures, to maintain vacua, and so forth. All these things are the subject of Record and Comparison, and what is easier than to make the results public property as far as the group concerned in establishing them is concerned? One day the fuel consumption will be high and another low; one day the pressure will fall off through someone's fault, or by some accidental cause; perhaps another day some heavy demand will be experienced and successfully met—a matter of pride to those responsible.

These seem trifling matters compared with the total life of the whole plant, but if *judiciously* made public, they would afford subjects of comment, of discussion, of gossip if you will, to the power-plant group, and tend to make each one realize that he was engaged in an interesting occupation, on which a great deal depended.

Similarly, with regard to that part of the Equipment group concerned with maintenance and repair. Here a clean slate would be the thing to aim at, but it would perhaps rarely be realized. The prevention of accidents, of breakdowns and delays, would certainly be assisted, if each event was published, with *judicious* comments on its results, and on what might have been done to prevent it. Again, a repair staff has frequently to work hard and long on some urgent repair. What more likely to give encouragement than some means of public recognition of such work, some bulletin notice giving credit where it was due?

In the above suggestions we have underlined the word "judicious", for that is the kernel of the problem. It has already been remarked that the fostering of *esprit de corps* is in the end a matter of personality. The mechanism just described is only mechanism—whether it be successful or not will depend on the personality of the higher official who is entrusted with apportioning praise and blame. A very judicial as well as judicious man is necessary. The object is not to establish a mutual-admiration society, neither is it to set up an engine of scolding and worrying. Either of these tendencies will defeat the object in view. Even-tempered justice is the first requisite for any measure of the sort. Men will always respect justice in the long run even if sometimes it falls on themselves.

Team work and co-operation are not the same thing as *esprit de corps,* though they are an essential element of it. Neither of them, however, is usually more than the response to some unusual stimulus or incentive, unless they are actually the outcome of an existing *esprit de corps.* Therefore they are rather a result of *esprit de corps,* generated by it in the natural course of events. They cannot be permanently established without it. To speak therefore of a spirit of co-operation is rather a misnomer. Co-operation is not an end in itself; it is a result of something. Men will not co-operate for the sake of co-operating, but they will co-operate to gain some definite end. This end may be a tangible one, like some special bonus, or an intangible one like upholding the honor of the flag, or the credit of the plant. It is hardly necessary to state that the latter class of co-operation is the most valuable, because it alone is due to *esprit de corps,* that is to *a larger issue that controls the will of men unconsciously.*

While good physical conditions, as indicated by the first sub-principle of the Third Law of Effort, do not give rise to *esprit de corps* they are a valuable influence in its favor. But the moral atmosphere is still more important—that is, whether or not the worker feels that he has fair play, that his efforts are appreciated, that he is treated as a man and not as a child or a piece of mechanism, and that he is a working and indispensable unit in a large whole, of which he can, to some extent at least, perceive the objective and the drift.

Since the above was written a recent contributor to a technical paper has given what purports to be the gist of a shop conversation over the after-dinner pipe, on the subject of "What makes a shop pleasant to men". From this is extracted the following word picture of the men's idea of a good shop:—

The talk became general, and several things came out very plainly. The shops that offered steady work at the highest prices seemed to have the most friends, but it took quite a difference in wages to offset some other things. The highest praise for a shop was not beautiful buildings, or welfare work, but was told in an expression that every man who had been around much seemed to fully understand, and it was: "and they treat you right."

While these men all seemed to comprehend the meaning and high praise of the expression, it is one that is not easy to interpret to the man who is not a shop man from the bottom up, but in general terms it meant a shop with a sufficient mixture of the following good points.

The men in authority understood the work and judged fairly of a man's accomplishments. Needed assistance was easy to get when needed; accidents and bad work were investigated before judgment was pronounced; work was so provided that a man did not need to worry about a supply of it; a sufficient quantity of accessories was readily available; troubles and dissatisfaction could be told to someone with power to act; enough attention was paid to individuals to tell a good man from a poor one. The system used, as it touched the men, seemed reasonable and necessary; the ones in authority acted as though they recognized that shop men were also intelligent human beings with some brains; a moral atmosphere that seemed to assume that the men were willing and trying to do right by the shop.

This last point may not appeal to some as belonging to a machine shop, but it is a very real one for all of that. In some shops the system, or the way it is applied, seems to say: "You are naturally a stinker, but we are on to you and it won't go here. We can and will keep track of you from the minute you come in in the morning until you get out of the door at night, so get right in line and stay there, or out you go."

In other shops the system, or the way it is applied, seems to assume that the men are reasonably honest and willing, and only need directing instead of watching. Applied long enough and rigidly enough each shop will be found to tend toward being filled with such men as the system fits, and it is because of the management, and should not be blamed on the men.

Among the things that were most often complained of about unpopular shops were unjust treatment by foremen; supercilious treatment by some cheap clerk, whose position made him an errand boy between the shop and the office, but who acted, and was allowed to act, as though he was owner, or more, for a man with brains enough to be owner seldom acts in that way; an insufficient supply of such things as bolts, clamps, dogs, chisels, files, and so forth. It is surprising to know that this is a complaint that is made against some shops that are called up-to-date. Shops in which the tools and the shops are modern, but where the work is held back because of the little things, and the ceremony and trouble which attend getting a needed quantity of them. —W. OSBORN, in *American Machinist*, Mar. 12, 1914.

CHAPTER XI

PRACTICAL APPLICATION OF THE THIRD LAW OF EFFORT (*Continued*)

INCENTIVE

THE fourth sub-principle of the Second Law of Effort is to the effect that "effort must be remunerated".* In applying this sub-principle to each Function its aim was declared to be the isolation of specially valuable kinds of effort for the application of incentive. The Second Law of Effort does not pretend to deal with Incentive as such, but only occupies itself with finding out what types of effort are specially important in each function. It remains therefore to complete this by considering Incentive in the abstract—what it is, how it acts and what its range or scope should be. This brings us to the sixth sub-principle of the Third Law of Effort: namely, that:—

*See Chapter VIII, page 196.

6. Incentive must be proportioned to effort expected

The first question we have to ask is "What is Incentive?" The answer is, in general terms, that incentive is that which moves human beings to effort. The less incentive, the less effort. The sociological law of Parsimony tells us that human beings will always seek the path of least effort to attain a given end; consequently we find that in those countries where, as in the tropics, life can be maintained by men with almost as much ease as by vegetables, absence of incentive results in absence of effort, and men vegetate in sloth without trying to rise to greater levels of culture.

Incentive may be natural or artificial. It may arise from the spur of Nature or from the needs of civilization. Hunger, cold, and wet are examples of the first. Each of them is an incentive to man to get up and do something for himself. These spurs are also felt in civilized society by the weak or unfortunate, but to the great mass of civilized men these iron hands are concealed by the velvet glove of employment. The employed man, however humble, is at least freed from the stern incentives of hunger, cold, and wet.

From this point we pass upwards. All men are not alike, either in their powers or aspirations. The strange but universal law of Average in Faculty shows that in every large unorganized group of men, the great mass will have a medium development of faculty, and above and below this mass will be smaller masses having development both above and below the average. As we near the confines of the curve, we shall find that a relatively few individuals will have extremely low development and about the same number will have extremely high development.* This sociological law appears to hold good for whatever faculty, moral or mental, we examine great masses of men. Now the principle of Incentive rests on this—that hardly any men, except those whose development is far below the average, are free from a desire to progress a little, to enjoy more, to receive more consideration from their fellows, to do a little better on the whole than they did at the outset.

This at once brings us to an important element in Incentive. It may be either moral or material. If for the most part it is material at the present day, that is because we

* "Human Faculty," Sir Francis Galton.

have fallen into the habit just at present of valuing a man by the amount of his material possessions. Millions are more easily recognizable than worth, and not only more recognizable, but much less easily counterfeited. But even today, material incentive has not the whole field to itself. Fame, honor and public esteem have not ceased to be incentives, though they are less powerful incentives than formerly. Even in industry, which is in itself merely the development of material resources, men respond to other incentives than dollars, and this being so the matter becomes of practical importance.

Having defined Incentive as that which moves men to effort, we may next ask in what way does Incentive act? Can we overdo Incentive? If men are of various grades of capacity must the Incentive be graded in correspondence? If Incentive is of two kinds, moral and material, do these forms act in dissimilar ways? If so, is it possible to combine them to act on the individual? Can Incentive be made to assist in fostering habit and *esprit de corps?* All of these are very important questions, and we shall find that all of them can be answered in the affirmative.

All of these questions are in fact summed up in our sixth sub-principle that "Incentive must be proportioned to Effort expected". That we can overdo Incentive seems easily deducible from the sub-principle, and in fact it is easy to overdo it. If we offer too large a reward for a given result, one of several unexpected things may happen. First, if, as is assumed in the premises, the reward is beyond what the man would normally expect, he will quite possibly not go all the distance after it. He will be content with doing part of the work, and getting part of the reward. In some trades, particularly in England, where wages have been forced up by powerful trade unions high above the average of the class, the workers in these trades will not work a full week; they prefer to make what they consider sufficient for their wants, and idle the rest of the time. This is a clear case of over-incentive.

On the other hand, we can produce equally mischievous results on another type of man, by offering too high a reward. In his effort to attain it he will spend himself too freely, using all his reserve strength, and injuring his health. This is, in fact, one of the main grounds on which trade unions base their objections to systems of payment by results.

It is worthy of remark that society in its gradations, its president or ruler, its legislators, judges, great preachers or ecclesiastics, leaders of science and art, captains of industry, etc., its vast mass of ordinary men, and its sub-stratum of the unfortunate and the incapable, corresponds very closely to the distribution of faculty as revealed by the law of average in Faculty above mentioned. The supply of capable men is not inexhaustible, the supply of more than usually competent men must always be small. We have heard of late a university professor lamenting the incapacity of a large fraction of students to profit by the widespread facilities for higher education that have been so liberally established and endowed in America. His opinion is that young men are being attracted out of their proper orbit, that thousands aspire to higher positions which they are naturally incompetent to attain, and they make the time-honored mistake of supposing that education will turn incapacity for leadership into capacity for it.

In the industrial field, there are also many grades from the president at the top to the shop sweeper at the bottom of the scale. It is the just boast of our society that nothing prevents the sweeper from mounting until he fills the chair of the president. As regards the individual this is satisfactory and spectacular, but if we regard either society at large or the industrial field in particular, we shall see that cases of this kind are numerically very few, so few that the law of average is not thereby disturbed at all. We are therefore left face-to-face with the fact that both social and industrial organization is an affair of gradations, mobile as regards the individual, but permanent as regards men in the mass. Though men are actually passing all the time from one grade to another, both upward and downward, the proportion in each grade remains constant.

To confine our attention to industrial matters, we will observe how this permanent system of gradations is affected by Incentive, because it is evident that a right understanding of the matter is very important. If we suppose that any man can be spurred by incentive to attain any end, this is equivalent to saying that whole grades of men can be moved upward by the application of incentive. On the other hand, if we regard grades of faculty as permanent phenomena of society, then it is obvious that our task must be to adapt and proportion the incentive rather to the grade than to the individual.

In practical language this means that in fixing the incentive for any particular kind of work, we must regard the customary wages for that trade, calling, or profession. For customary wages are a natural growth or evolution and have been worked out instinctively and by the process of trial and error through generations. For certain work it has been found necessary to attract certain grades of faculty, and this can only be done by paying the customary wages* or market price of that grade of faculty. The more difficult the work, the rarer the faculty that will handle it, and consequently the higher the market price for that grade of faculty. When we speak of "Incentive being proportioned to Effort expected", therefore, we really mean that it must be proportioned to the grade of faculty concerned, and to the customary wages for that grade of fac-

* For a discussion of customary wages in the general labor problem, see Appendix I.

ulty. If we offer too little, the right grade of faculty will not respond; if we offer too much we are not only wasting money, but making individuals dissatisfied with the customary wages of their grade to no permanent purpose.

In applying Incentive, therefore, our aim must be, not to extract higher-grade activities from men than they naturally possess, *but to promote the full development and use of those faculties they may be reasonably expected to possess.* If this seems to neglect the interests of the meritorious individual, the answer must be that the meritorious individual is usually able to take care of himself. When a man realizes that he possesses faculties superior to those called for in his work, it is obvious that this affects the market price of his efforts, but not the market price of the work on which he is actually engaged. One of the most difficult practical problems of large undertakings arises from just this position of affairs—the grade of faculty of many men, though not of all, rises as they get older. To recognize this, and to keep such men by finding the right place for them as they develop, is no easy managerial task.

Having thus defined the aim that should be observed in creating Incentive, we may now consider the forms of Incentive—moral and material—with a view to ascertain what varieties of these can be applied in industrial practice.

Moral incentive is based on a natural human instinct, that of emulation. The desire to surpass his fellows, to shine amongst them, even to arouse envy in them, is as well marked a passion in human nature as any other. Badly directed it leads to notoriety-seeking, and even to criminality; but rightly directed it provides a good deal of the motive power of civilized society, from the days of childhood onwards. Moreover, individual progress is very often due to a kind of self-emulation,—a desire to mark one's own progress, and establish new records. Many workers engaged on monotonous tasks contrive to invest them with interest by running, as it were, races with themselves, trying out first this way and then that, and keeping count of the results of one method compared with that of another. From which, by the way, the undesirability of despotic insistence on "one best way" of doing routine work may be deduced.

The use of emulation as a form of Incentive, should, however, be made with caution. What we require in industry is not sudden, spasmodic effort, based on straining faculties, whether mental or physical, but steady day-after-day effort. It follows therefore that *emulation must be made use of to foment interest rather than to force the pace.* On a walking tour, a great deal of the interest arises from the sense of progress made, of ground covered, of so much done. Walking without an objective point, or walking in a country without landmarks, without milestones, so that the progress we make cannot be measured, loses half its pleasure. Yet it does not follow that the presence of milestones makes us walk faster or unduly hurry ourselves. On the contrary, our progress will be more even and sure, our pace steadier, and our condition of fitness better preserved, if we are able to mark our progress at frequent intervals, and observe what proportion the intensity of our effort bears to the attainment of our goal.

The moral varieties of Incentive therefore should be so arranged that they give rise to emulation of an invigorating and not of an exhausting nature. In the last chapter we sketched a proposal for promoting *esprit de corps* in the power-plant staff, based on the simple idea of publicity of certain data of interest to such staff. Such a form of publicity also arouses emulation, the desire to maintain good records, not to slip back, on the contrary to make a little progress forward when opportunity offers. It is, then, a form of Incentive, and it can, moreover, be converted from a moral to a material incentive by the equally simple step of attaching some bonus, or small increase of pay, to the maintenance of satisfactory conditions and to the improvement of the record.

It must be noted that there is a great difference both in aim and result between incentive applied in this way, and the ordinary individual piece-work or bonus system. The latter has its place, of course, and is not excluded by, nor does it exclude, the former. The one is individual; the other is, in a small way, social. Both appeal to the self-interest of men, but in a wholly different way. The one appeals to self-interest alone, the other appeals to group-pride. The one has but small moral invigoration in it, the other has much. The one concentrates, the other broadens the faculties—both excellent things in their way, but of the two the latter has probably the most lasting and satisfactory influence.

At the beginning of this chapter, two of the questions we asked were:—If incentive is of two kinds, moral and material, do these forms act in dissimilar ways? If so is it possible to combine them to act on the individual? We can now see that both the answers are in the affirmative. Moral incentive is different in its action from material incentive, for it appeals to higher instincts, and it can be combined with material incentive so that both act in the same direction.

The mistake must not be made of confusing what may be termed "collective bonus" with the form of incentive above mentioned. The essential feature in the plan proposed is not the material reward, but the moral stimulus. It is not that we reward a group of men with some few extra dollars, but that we let a group of men know when and how they have reached certain results. The few extra dollars give additional interest to the result, much as some people cannot play a game of cards without having something "on" the game. But the average man does not play cards for what he makes out of it; he plays cards for interest and excitement, the stake being only incidental. The nearer we study the everyday actions of men and the motives that prompt them, the nearer we shall be to devising methods of industrial incentive that will give interest to life, and thereby invigorate the worker.

The aim of Incentive should be, then, *both to arouse interest in a broad result, and to reward individual diligence in helping to attain that result.* As has already been mentioned, this principle has been adopted by several firms in promoting efficiency among their selling staff, but very little progress has been made in applying it to the factory. It cannot be doubted, however, that it can be and should be applied to all departments of business, if only because it arouses group-consciousness and group-pride.

The practical application of incentive is obviously a matter of great variety, differing in each industry and in each plant. It is not our desire here to offer concrete suggestions or fully worked out plans, but to consider the underlying principles of concrete devices. We will therefore confine our attention to formulating in practical language some of the conditions that should be observed in setting up forms of incentive.

First we have the natural divisions of Effort as marked out by the existence of the Organic Functions. Thus we have effort applied to the designing function, to the equipment, to the controlling, the comparison and to the operation functions. It is only in very simple businesses that we may expect to find it possible to apply any form of incentive to all these functions collectively. In most cases, separate forms of incentive, dealing with separate kinds of efficiency, must be set up for the work of each function.

Then as regards the work of any one function, the important efficiencies must be isolated (as indicated by the sub-principle of the Second Law of Effort that "Effort must be Remunerated") and thereafter analyzed and considered, as in the case of the power-plant staff already referred to, so as to disclose the data on which incentive should be based. If for example, the ratio of pounds of fuel burned to pound of steam generated is within the power of the staff to control, then this item of efficiency will be one of the bases. If the keeping up of a certain pressure at all times is similarly dependent on the efficiency of service, this will be another base. If pressures, temperatures, vacua or voltages have to be varied from time to time according to conditions, then the closeness with which the variations are kept to the change in conditions will be another base.

Now these elements can be made the basis of individual bonus, in some cases—the stokers, for example, can be rewarded on the separate efficiency of their work—and a general efficiency factor based upon the various separate efficiencies can be made the base of a group-incentive. In the latter case the important point will be not so much the distribution of a certain amount of money as a general power-plant efficiency bonus, but rather the publication of the data on which such bonus is based in such form that all concerned can compare results from one month or period to another.

It can hardly fail to be noticed that we are here arranging incentive somewhat on the lines both of analysis and synthesis. We reward the ultimate division of unit operations, say for example, the stokers, and we also synthesize certain kinds of effort, which are closely related to each other, and arrange another kind of incentive on the result of this synthesis. By so doing we proportion incentive not only to individual effort, but to group effort also. We comply with the principles deduced above, viz.:—we promote the use of faculties which each man can be reasonably supposed to possess, and we both arouse interest in a broad result, and reward individual diligence in attaining that result. As a by-product of this arrangement we also promote group-consciousness and therefore group-pride or *esprit de corps* in a way that no form of incentive applied solely to the individual can possibly do.

The subject of incentive as applied to operation, that is, to the individual operator, has been much more widely discussed than any other. The modern tendency is to base it on a careful analysis of the amount of effort required for each job, and this is studied by means of time study and motion study. It must not be forgotten, however, that time and motion study are methods of analysis of effort, and not measuring rods for wages. This has been vehemently denied, but it is obviously so. Wages depend on custom—that is, on the experience of both employer and employee over a series of years as to what is the proper price to pay for certain grades of skill. It is true that, in some cases, time and motion study have revealed that certain work can be done by a lower grade of skill, and therefore for less wages than was thought possible. This, however, is a comparatively unusual discovery. Wages are commonly fixed by custom, and analysis simply defines how many of a certain thing can be handled efficiently in the course of a day's work. It has nothing to do with fixing the customary price to be paid for that grade of work. Much of the hostility of workmen to these useful methods of analysis is due to a misapprehension of this fact, for which it must be confessed the wild claims made by the less responsible followers of the school of "scientific management" are largely responsible. The whole subject of incentive in operation has been discussed in Appendix I under the title of "The Labor Question".

There is one form of Incentive that may possibly assume more importance in the future than it has in the past, namely, the so-called profit-sharing. But while it satisfies one of the conditions laid down here, in that it tends to interest the employees in a broad result, it appears to lack somewhat of the other half of the same condition, namely the rewarding of *individual* diligence in helping to attain that result. In other words the defect of the plan appears to be that the reward is too remote. Nevertheless, in so far as it brings into focus the idea that all industry is in effect a partnership, it must be commended if only as an antidote to the pernicious theory of socialistic or anarchistic agitators, that labor is the source of all wealth.

In a broad and academic sense this is, of course, true. Matter being inert, it is evident that it does not build itself into forms of wealth. But neither is it built into forms of wealth by labor alone, either by manual or mental labor. Both these have to be organized and synthesized before they can effect any more efficient conversion into wealth than is found in the wigwam of the primitive savage. All the rest depends, first on a conception of an objective, and the means to realize this objective. Second, on the organization of mental and manual labor into effective functional activities to attain these ends—one of these functional activities in industry at large being the manipulation of the secreted or stored energy of the community, known as Finance. Now it is just this power of conception and this power of synthesis and organization that are somewhat rare in the world, and like all rare things, have their market price, which is high. Labor in the ordinary sense has no part in these creative activities, but is only taken into partnership at a later stage. It is, of course, "worthy of its hire" and everyone wishes that its rate of hire should be as high as reasonably possible; but it is not the only factor of wealth, nor even the most important one.

The proof of the proposition that labor is not the most important factor in creating wealth is in the lamentable fact that it is frequently a drug in the market, and cannot find any outlet for its powers. Why is this? It is that the supply of labor has for the time outrun the capacity of the organizing element to create new openings. It is a common phenomenon to find great unemployment of labor and at the same time great unemployment of capital. Yet anyone who sees a way of using either to good advantage can usually find an opportunity of doing so. If there are times when it is not done, it is because it cannot be done. The world is at that moment awaiting some constructive concept to set things in motion. Shrewd men, searching the world for opportunity, naturally expect to be paid well for their efforts, and for their capacity, when they succeed.

While profit-sharing is a valuable idea as far as it helps labor to realize the true nature of the problems of industry, it does not seem at present to have attained a development of great promise. It is possible, however, that it contains a valuable germ, and will attain greater usefulness in the future.

TABLE XIII. APPLICATION OF THE THIRD LAW OF EFFORT

Personal Effectiveness Must Be Promoted

First sub-principle:—
Good physical conditions and environment must be maintained.

Second sub-principle:—
The vocation, task, or duty should be analyzed to determine the special human faculty concerned.

Third sub-principle:—
Tests should be applied to determine in what degree candidates possess special faculty.

Fourth sub-principle:—
Habit should be formed on standardized bases, old or new.

Fifth sub-principle:—
Esprit de corps must be fostered.

Sixth sub-principle:—
Incentive must be proportioned to effort expected.

Chapter XII

THE MANAGER AND THE INSTRUMENTS OF MANAGEMENT

THE whole subject of the Organic Functions of manufacturing industry and the Laws of Effort that control them has now been developed. In the present chapter it is proposed to review the matter generally, and supplement it by some observations on the relations of the manager to the science of management.

It has been shown that production is a synthesis of certain well-marked functions. Each one of these functions is essential to production in some measure, though their relative importance varies in different industries. In some the function of Design is very elementary, in others Equipment is less complex than in others. Again there are industries easily yielding to Control, and others in which a considerable proportion of the total number employed is engaged in one variety or other of the controlling function. The same applies to the function of Comparison. Operation alone has an equal importance in all industries, because like the fighting force of an army, it is the function to which all the other functions minister. But of course, it does not always reach the same complexity, either in variety of different kinds of skill concerned, or in the difficulty of performing the acts of operation.

No other activity of production exists outside these five Organic Functions. If any exists it is optional, such as certain kinds of welfare work, which are however really administrative acts touching, or supposed to be touching, on the promotion of personal efficiency. If they are functioned at all, they are derivatives or branches of the function of Control.

Efficiency in production is dependent, and alone dependent, on successful synthesis of functional activity. As regards each function the Laws of Effort point out what has to be done, but these laws do not apply themselves—they are applied. What then applies them, and what so consolidates the working of the Organic Functions that efficiency is realized? There is only one answer to this question, namely—the synthetic influence of a strong personality. Both the Organic

Functions and the Laws of Effort deal with relationships between living beings,—these are the only material with which the science of management has to deal. It is the association of men for various objects that alone gives rise to industry, and it is the successful synthesis of their efforts that gives rise to efficient industry.

In all history there are but few examples of armies that have done great things without two elements being present: first, great leadership; secondly, great discipline—that is, the capacity of men for following leadership. On the other hand there have been innumerable instances where a change of leaders has transformed an unsuccessful into a triumphant army, and also cases where the reverse has taken place. Above all, therefore, what is necessary to efficiency, is leadership.

Management is the science of applied human effort, just as chemistry is the science of applied chemical properties of elements and their compounds. In either case, above and outside the natural reactions which it is the *rôle* of the science to study, a controlling human agent is tacitly implied. If management implies a manager, chemistry implies a chemist. Each of these men sets out to produce result by manipulating the material at his command, subject to the laws of his science, and whatever he attains he attains by skilful synthesis. But both the manager and the chemist act on and through the science, outside which they themselves stand. In either case the man brings to his aid a synthetic action which is purely individual and uses the facts and laws of science to produce a result that must first exist in his own brain.

This seems to show that the manager, the leader, must bring something into the solution of his problem beyond the science with which he works. It is not sufficient for a man to understand chemical, or military, or management science to make him a great and successful worker in these fields. There is evidently something more needed, something subtle, something which it is not possible to define with precision, but which is summed up in the very vague but well understood word ''capacity''. Probably one of the great components of capacity is a strong and unusual sense of proportion, a quantitative sense which tells him not only which way to go, but how far to go.

We come here to a paradox, namely that the science of management cannot produce managers. But neither can military science produce generals. In both cases study of the science can assist, can help them to systematize their work, does put them in possession of the accumulated experience of the past as regards the success or non-success of principles that have been tried out long ago; but the great leader is after all born and not made.

We come back therefore to a picture of a man of capacity using two great instruments —synthesis and analysis—to attain the ends that seem fit to him. In the foregoing chapters we have tried to depict something of the nature of the material with which he must work—the functional activity of his men; and further, certain observed influences or laws that control this activity have been discussed. These are the warp and weft of the fabric he has to create, but the fabric itself will be a result of the way in which he combines these elements. His work is to adapt these general truths to particular circumstances, just as the general of an army has to adapt the rules of military science to the changing necessities of a campaign.

In the foregoing chapters we have exhibited the skeleton and framework of the science of management in manufacturing. We have defined the scope of the five Organic Functions, and have shown the wholly dissimilar nature of their aims and objects, and the impossibility of supposing that these aims are in any way interchangeable. We cannot conceive that an act of Design can ever give rise to material product, or that an act of Operation (that is, the exercise of a machine process or a trade or skill) can ever produce a new design. Similarly the mechanism and organization of Control and of Comparison have obviously such different aims that we cannot conceive an act of Control ever comparing anything, or *vice-versa.* Equipment also, being the function which provides physical conditions, is evidently an inert or passive function. It represents a plant in full working order, it is true, but not necessarily working. The vast reach and influence of Equipment is best realized by walking through a large plant when it is deserted by the living factors of production, and Equipment,—dead, inert Equipment, is in sole possession of the field. At such a moment one does not need to be reminded that Equipment is indeed a thing apart, and that, by itself, it is incapable of producing product, or of exercising the functions of Control, Comparison or Design.

Across these functional activities, the synthesis of which alone makes a plant in active operation, we have seen certain Laws of Effort weaving a fabric of custom and habit. For it must be understood that these Laws of Effort,—like all other natural "laws"—are merely the recorded results of phenomena which have been so often observed to happen in the same way that we are justified to consider them indefinitely repeatable under similar circumstances. When we say that to produce fine results, "Experience must be systematically accumulated, standardized and applied", we are merely recording a particular industrial problem, in a particular way and applied to what is the universal observation of mankind. There can be no doubt about either the universality or the correctness of such a law, and what we have said about it that is in any way novel is to point out that it must be applied in manufacturing, not at large or vaguely, but in five different directions. We must accumulate, standardize and apply experience in Design, Equipment, Control, Comparison, and Operation. This alone gives definiteness to the law.

Similarly, the second Law of Effort, that Effort must be regulated in four ways, viz.:—by Dividing, Co-ordinating, Conserving and Remunerating it, is no new discovery. Expressed in less definite and technical phraseology it has been known from the beginning. But here again we may claim to have given some definiteness to this universal law, by pointing out that each of the five functional activities concerned in production are subject to this law, and that naturally it produces different effects in each. This law, like the others, has not been invented, but observed—it has always existed.

Finally, we come to the Third Law of Effort, which speaks of the conditions necessary for the promotion of personal effectiveness in the work of production. Here again we have nothing but well-worn truths, assembled and grouped so that their application to the particular problem of manufacturing management may be studied at leisure. But this law does not apply to Functional activity as such. It deals with each individual as an individual. The first sub-principle, indeed, is modified in application according to whom it is applied, since "good physical conditions" for one kind of work are not the same as those demanded for another. But they have no connection with the functions as such. Take for example, the question of quiet surroundings. The higher officers in each function have need of much quieter surroundings than the rank and file. The accountant has one standard of quiet, but the weighman at the cupola, even though engaged on the same functional activity, viz., record and comparison, need not be safeguarded in the same degree. The draftsman, again, must have a high degree of quiet, but the time-study man frequently carries on his operations in the shop itself with perfect comfort and success. Hence the application of even this first sub-principle cannot be regarded as divisible by functions.

The remaining sub-principles of the third Law have even less specialized application. They deal with four very important but quite abstract ideas—vocational fitness, habit, *esprit de corps,* and incentive. Some day, no doubt, all these matters will have been studied in so much detail that their specific application to functions may seem feasible and necessary. But as yet this is not the case, and these matters have to be dealt with in the abstract.

On the subject of vocational fitness and the tests to be applied in order to discover it, we have thought it necessary to call attention to the warning of Professor Muensterberg with regard to the use of psychological methods of analyzing faculty. Already a good deal of quackery has developed in this direction, and methods not far removed from the old and exploded phrenological absurdity of determining character by "feeling the bumps" have been put forward for serious acceptance. The determining of vocational fitness is of course no new thing. Every employer uses it to a greater or less degree when he engages an office boy on the strength of his handwriting, his testimonials, and the personal impression he makes. The newer ideas in this direction simply seek to discover, first better and more exact grounds for determining vocational fitness of a simple order, and secondly for determining fitness of a complex order such as the work of a motorman spoken of in Chapter IX (see page 228).

The formation of correct industrial habit has been dealt with as the fourth sub-principle of the Third Law of Effort. Here again we have not dealt with a catalogue of habits desirable or undesirable in regard to Functional activities. It is the general principle that habit should be formed on standardized bases that has been laid down. It has been shown that these need not be new bases. Thus the habit of punctuality is certainly a conformity to standard, but the standard is very old. Where, however, analysis has shown old standards of performance to be faulty, then new standards when determined should be passed into habit as soon as possible. Thus if motion study applied to a particular kind of work demonstrates that the old habitual way of doing it was wrong, it is eminently desirable that the new method should be established as a tradition, that is, as a habit, as soon as possible. Every habit customary today began at some time or other, and most have been subject to modification many times in their history. But each alteration, each improvement, has resulted in new habit being formed, and though "written instructions" are sometimes a necessary stage in the process of forming new industrial habit, they should be regarded as an unavoidable nuisance, and not carried too far, or too long. Of course, in one sense, every technical text-book is an example of written instructions, but no practical man is always running to a text book for guidance in his daily work. He gathers from such books the practice he desires to adopt, and this practice then becomes part of his practical habit.

Considerable space has been devoted to an examination of the fifth sub-principle that "*esprit de corps* should be fostered", because the wide attention that has been given to analytical methods in recent years has almost submerged the synthetical demands of management. Much more attention has been given to considering the problem of production microscopically, than to considering it as a whole. Though it is true that a whole is made up of parts, as a house is of bricks, there is more in management than the fitting together of microscopic details, just as there is more in architecture than the placing one brick on another in a neat and workmanlike manner.

Among the synthetical processes that have been somewhat neglected lately, this of *esprit de corps* may be noticed. True, a great deal has been heard about the desirability of a spirit of co-operation—although as we have pointed out, *esprit de corps* means much more than mere co-operation—but even a spirit of co-operation does not arise from a combination of mechanisms; it arises from the perception of larger issues than are contained in any mechanism. Men do not co-operate merely because it is a good thing to do in the abstract; they co-operate because co-operation comes naturally to them.

Now the real motive force is rarely or never due to the matter having been reasoned out by the individuals concerned. Men rarely or never get together and say, "let us co-operate". On the contrary, the act of co-operation is really a polarization of wills due to some outside influence, just as a host of little magnets all turn in one direction when enveloped by a magnetic field, and this outside influence is still more rarely self-interest. Where true co-operation exists it is usually unconscious, and due to the fact that a high development of *esprit de corps* exists. And as we have shown, *esprit de corps* is a complex and subtle atmosphere, largely emanating from personality — the personality of those in control.

The last of the sub-principles of the Third Law of Effort that "incentive must be proportioned to effort expected" is also of a general and abstract character. It is an examination into the nature and elements of incentive that we have made, rather than a prescription of definite methods of setting up efficiency rewards. It was found that different and well recognized gradations of skill are present in the industrial field, and that each of these has its customary wage. The object of incentive was found to be, not an attempt to raise men of one grade to another and higher grade, for that is their personal affair, but to call out the *full use* of the faculties that may be reasonably expected to be possessed in any given grade. In the course of doing this, emulation may be aroused, but on condition that it is used to arouse interest in the work rather than to force the pace. There is in fact, in all questions of incentive, a group aspect as well as an individual aspect, and the best form of incentive will be that which combines both of these. Here, again, the tendency of late years has perhaps been to concentrate attention on spurring the individual, to the neglect of the equally important task of fostering *esprit de corps* by arousing interest in the group.

We are now at the end of our task, which was to exhibit and delimit the five Organic Functions of manufacturing management and demonstrate how the three Laws of Effort influence their working. In a work of this kind, containing so many details, it is possible that errors have been made, and even that some small inconsistencies may be discovered. But it is believed that the broad outlines are correctly presented, and that we are here in presence of some few fundamental facts and Laws, which can be reasoned about, and practically applied. They may be considered, therefore, the commencement of a formal science of management.

In the chapters that follow, a brief glance will be given at the task of the practical organization of the five Organic Functions. Machine manufacturing has been selected as a case in point chiefly because it is more complex than most other forms of industry, and manufacturers of other classes of product will have to ignore much that does not apply to their industry, leaving intact what does so apply. To assist the latter class of reader, however, a diagram has been prepared, showing application of the five functions to a more simple form of industry than machine manufacture.

PART II

ORGANIZING THE ORGANIC FUNCTIONS

In order to illustrate the practical organization of the Organic Functions, machine manufacture is taken as an example, because it represents what is probably the most complex kind of industry. In order to correlate the particulars thus given to other industries, all that does not apply should be omitted. Thus the function of Design in some industries is quite rudimentary, being represented by the writing of a chemical formula. Similarly in some industries the function of Control is quite a simple matter, in others it demands an elaborate organization. Generally speaking the following chapters refer to what may be considered as a maximum development in each function.

Chapter XIII

ORGANIZING THE FUNCTION OF DESIGN

THE first stage in establishing a plant is to decide on the product to be manufactured. Its design for technical use should then be undertaken. The preparation of designs for use does not come within the scope of this book, which deals exclusively with production. In fact it does not follow that such design is prepared by the manufacturer at all. Not infrequently complete designs of the machine are supplied by the inventor or other person putting the product on the market. It must be assumed that whoever is responsible has applied the First Law of Effort and that he has availed himself of all the experience obtainable with regard to the technical and commercial value of his design.

We do not need to consider, therefore, the efficiency of the machine as a whole, or what may be termed its technical efficiency. This belongs to the problem of the ultimate use and value of the product, with which we, as considering the manufacturing problem purely, are not concerned. Whether the ship we are building will prove a dividend earner for her owner, whether the shoes we are manufacturing will prove acceptable to the demands of fashion, or whether the machines we are building will do what they are alleged to do, are interesting points, very important to continued *commercial* success, but they are not *manufacturing* problems.

In all such cases we must assume that the product is a well thought out product, as far as its uses go. It is only after that question has been settled that manufacture can be safely undertaken, because by manufacture we mean making in quantity. Therefore it is well to point out that Design has two sharply defined sides—*design for technical excellence of use,* and *subsequent* scrutiny and possible modification of such design *with a view to manufacture.*

Having decided on the product and having accepted its general design for use, the series of operations which are embraced in the term production may be said to commence. These begin with:—

1. Organization of a drafting-room force capable of undertaking design for manufacture, *i. e.,* modifying the design of parts or components so as to bring them into a form suitable for the most economical manufacture.

2. Analysis of the machine or product into components or parts suitable for manufacture, by means of:—

3. Division of Effort. Having divided the product into units of simplest form and construction, the machine processes, skills, and trades which are the units of Operation must be mentally applied to each piece. If necessary the design of components must be varied to enable these units of operation to be applied successfully and directly. Successful design for manufacture depends on units of design corresponding exactly with units of operation.

4. Co-ordination of Effort. Having set up units of Design they must be carefully scrutinized to see that they will ultimately meet together exactly without ''gap or overlap''. In mechanical work this means careful attention to ''fits, limits and tolerances''. In some industries it implies correct specification of ''allowances or margins''.

Want of co-ordination is a very expensive kind of inaccuracy. Having once divided effort, it becomes necessary to foresee how the separate products of such divided effort come together again, to form a whole.

In practice a "fit" may be all the way from an affair which requires the parts to be hacked, filed, anathemized and forced into place, to a simple bringing together of two components, and a slight tap with a mallet.

A great deal of money is lost by lack of clear thinking *beforehand* as to the co-ordination of parts, otherwise of "fits."

The nature of the fit—that is, the accuracy of dimension to be imparted to the component—is, from the point of view of efficient manufacturing, nearly as important as the shape of the part. Either unnecessary accuracy or not enough runs woefully away with profits.

It will be evident that this is a source of confusion and loss that lies with the designer to obviate, and with no one else. The use of standard tables of clearances and tolerances will materially assist; but a lively sense of the loss that will be sustained by want of precision in indicating just what is necessary, *and no more,* will be still more useful. This can be brought about only by bringing such losses as they occur to the culprit's attention, and so forming a good tradition in the drafting room, namely, that the question of fits is, economically speaking, one of the most important questions that the draftsman has to solve.

5. Conservation of Effort. Units of design (that is, of product) must be capable of being made by the simplest operative skill. This implies, very often, the additional design of accessories, jigs, tools, *etc.,* so that simple skill can be applied with automatic precision. Standardization, or the principle of ''fewest things'', also arises from the necessity to conserve effort in regard to design. Parts, tools, and small accessories

should not be multiplied unnecessarily. Unnecessary accuracy or unnecessary finish should be eliminated by specification of the correct degree of finish to be given to the part.

Assuming that we have scrutinized our design, so that we are certain that there is no avoidable duplication of components or of elements, and that every item is in its ultimate simplest form, we wish to take means to preserve that simplicity in the future, and to prevent useless and harmful complexity creeping in, as it is sure to do unless we take energetic means to keep it out.

These means will vary in form according to the size and nature of the plant. Where the product is very simple, its components are few, and changes are made at infrequent intervals, very little more than a reasonable alertness, a good memory, and accurate observation on the part of the designer will serve to keep things from growing in complexity. But few plants are in this Arcadian condition. For the most part we shall have to rely on carefully made records, and not on anyone's memory, and these records when made will have several uses to be dealt with later.

Such records will take the form of a catalogue of components or parts of jigs and tools associated with them, and of auxiliary tools, such as drills, boring bars, taps, reamers, cutters, and so forth. A clear statement of the range and capacity of each machine should also be made.

It will be the duty of the designer to prevent accessions to this catalogue except when it is unavoidable.

It is no great task for each designer to familiarize himself with this "Book of the Plant". It should be his *vade mecum* and be with his thoughts at all times, both asleep and awake. If he trains himself to think in terms of it, a very large portion of the worries, complications, confusions, and errors that occur daily in every plant would be obviated.

There is a difference between rigidity of organization and definiteness of plan. This "Book of the Plant" is a case of the latter and not of the former. It prevents nothing, it insists on nothing, it stands in the way of nothing—the moment that it ceases to be up-to-date. We look on its extension with cold favor and a wary eye, but when it is necessary, it is the simplest thing in the world to do it. It is no obstructionist "system" that cannot be modified instantly necessity calls.

This is a case of applying experience to form standards. Our experience, in a new plant, begins with the determining of certain necessary elements. We record these elements as a coherent, related body of facts, once for all. As we gather more experience we add to the record. Later we may decide to eliminate part of our recorded experience from current practice, but our "Book of the Plant" always represents the conditions of the day—conditions that by this means have been kept at the zero-point of avoidable complexity.

In connection with the components of the product the question of naming or indicating them is sure to crop up. The modern tendency seems to be towards an alarming complexity of symbolization. Mixtures of letters and figures ten units long are not uncommon, and certain types of mind seem to glory in them. If it is a question of using long combinations, then there is little doubt that an abbreviated name is better. Many persons of quite good mental equipment cannot remember figures, and consequently run great risk of setting them down incorrectly. The ordinary workman is usually less liable to err with names than with figures. As businesses of considerable complexity, with very advanced methods, have not found it desirable to replace names by symbols, it would seem that it is to be avoided wherever possible.

Symbolizing is sometimes supposed to aid in systematic arrangement of stores, but as arrangement of stores is a physical affair, it is difficult to see why it cannot be arranged by names just as easily. Of course a certain amount of symbolizing is almost obvious, such as describing the different shops by letters or numbers, machines or processes by code letters, such as P for planing, etc.; but this is a different thing from such examples as "Lq34967-XPG," which is the fashionable variety of the art. Such shorthand may be very compact, but it is dangerous, tends to tie things up in "system", and its only excuse must be a very clear advantage, which so far is not clearly proven.

Nevertheless, whatever symbols *are* adopted, should be made common knowledge, and incorporated in the "Book of the Plant" so that there is no ambiguity in their use.

6. MATERIAL. Design specifies the nature and sometimes the properties of material to be used. It may specify the chemical composition and certain physical properties, such as hardness, elasticity, etc. It will be observed that is quite apart from the specifications of design already mentioned, all of

which deal with *changes* to be wrought on the status of material by the processes of operation.

Material and the work performed on it make up the whole story of production, for it must not be overlooked that all the functions (and these latter embrace every kind of mental and manual work in the plant) exist only for the purpose of making changes in the status of material in accordance with the behests of Design. Some of these activities, as the power-plant or the cost office, contribute only indirectly to the result, but they exist only for the sake of that result.

7. Specification of Details of Operation. The above proceedings, if properly carried out, have given rise to a design of a unit of product complete in all respects as to its physical and chemical composition (if our work is so particular as to require this refinement) but in any case complete as regards the physical shape of the part itself, with all its dimensions prescribed, and sometimes with a list of particular tools and accessories which should be used in the various processes to be employed in its manufacture. We have now to complete this design *by further specifications* which relate not to its physical appearance but to the details of the way it should be manufactured.

It will be remembered that it was laid down as a guiding principle that the work of the designer of components should be intimately connected with an exhaustive knowledge of operation units and the way that they can be applied to perform work. Hence it follows that in a properly designed component there will be a way of making it more natural than any other, namely, that method which was present to the mind of the designer when he was working out the design. Under such circumstances, to specify the method of manufacture is as natural as to specify dimensions, or accessory tools. But as this information applies only to the one individual piece, it is evidently merely a completion of the full act of design of that piece.

8. Organization of a Production-Department force as part of the general function of Design, capable of analyzing design units into details of operation, and of making time, and if desired, motion study of such details, with a view to complete the whole chain of specifications relating to the production of each component.

As will be referred to in more detail under the heading of "organizing the function of operation," a good deal of the time study necessary (where it is necessary) on individual components in the machine industry arises from the fact, firstly, that machine tools have a very wide range of duty compared with most industrial machines, and secondly, that very little systematic experience has been accumulated about their performances. Consequently there are few recognized standards of a general nature available. This involves separate study of operation detail for each component for which it is desired to specify time allowances accurately.

Applying the Second Law of Effort to the Operation Units on each component is the work of such a department. It first analyzes the operation into two groups, viz.,—steps necessary to prepare the material and the machine, and steps necessary to apply the machine process, trade, or skill to the work.

9. DIVISION OF EFFORT. Each step in preparation and in operation is considered separately, and a time study made of it.

10. CO-ORDINATION OF EFFORT. The various steps are scrutinized for "gap and overlap". Each step should carry the work a definite stage forward, so that the whole process is a series of independent steps in natural sequence.

11. CONSERVATION OF EFFORT. This involves a study of *method*. Alternative methods of handling work may exist; consequently when the importance of the job demands it, a further *analysis* is made, namely, of movements. This is commonly known as motion study.

After such an analysis has been made the shortest possible way of handling the work should be known, or, in other words, the way to do the job with the least expenditure of effort is disclosed. When necessary this information is incorporated with the specifications of Design, and becomes part of the working instructions for production of that part or component.

12. At this point the whole production history of the component has been embodied in instructions, which may be regarded as STANDARDS for the production of that piece. These will hold good until modified by experience in some particular. Thus, the chain of Design begins with the initial analysis of the machine or other product into components or parts. It ends when all that can be specified in advance about each component has been so specified.

It should be noted that the specifications of form, dimension and material are much more rigid than those of the detail of operation to be applied. The former must be observed exactly, since to depart from them would be to produce something else than what was intended. The latter, however, are merely indicative of what has been considered to be the best way of carrying out processes to comply with the rigid specification of form and dimension. But, if the exigencies of the shop demand, this specification of detail of operation may be departed from without endangering the production of the right kind of component. There will probably be a loss of another kind, namely, waste of effort. If the shortest and best way has been specified, then to make the component by another way means a loss of efficiency as regards the best use of labor and machinery. But in some cases this may not matter, the loss may be counterbalanced by gain in another direction, as in "rushing" a job through, or making use of an idle machine whose use was not contemplated in the specification.

13. We have now to consider the Function of Design as a whole. We have observed each step in its work; now we have to consider it as a function—that is, as a synthesis of individuals engaged on a common effort. At the outset we saw that application of the First Law of Effort was implied in acceptance of the initial designs. Now we have to note the application of that Law to the current work of the function. We began with certain accumulated experience, which formed our standards of departure, but it is also necessary to keep these standards up to date. To do this we must continually accumulate new experience, standardize it, and apply it, as the First Law of Effort dictates.

This demands a little organization. The work of the function of Design is very various, and also very important. There are many kinds of standards involved, and each of these requires watching and when necessary rectifying in accordance with experience. Without attempting to enumerate all of them, we may call attention to some of the more salient.

The object of the function being design for manufacture, it will be obvious that many problems will come up which will be more or less similar to problems already attacked and settled. Parts of similar shape, or having some similar peculiarity, when once they have been satisfactorily designed, form precedents, or as we may call them, standards, for all similar work. Therefore one of the wants of the Function will be a method of indexing and cross-indexing drawings and working instructions so that similar jobs may be quickly gathered for comparison and study.

This may sometimes give rise to a revision of the older methods of doing work. In studying over former jobs in the light of a new problem, new and better methods of doing work may be discovered. In such cases some method of noting a reference on the old specifications should be provided, so that when the work comes up for production again, the standard may be improved.

14. The same remarks apply to specification of details of operation, perhaps to an even greater extent. A good system of

classifying processes should give rise to a very complete mastery over the details of the sphere of action of every machine in the plant. In particular, preparation time should be studied in this way, so that an average of all common jobs for a given machine can be fixed. This, in its way, forms a standard preparation time for each machine, and jobs which exceed this standard average are evidently weak as regards holding fixtures or other details.

It has been pointed out elsewhere that most of the detailed study of operation necessary in machine-shop work arises from the fact that machine-tools are much more universal in their range than most others. In many industries, a machine will do only one thing and will do it in only one way. In other cases a change of work involves merely a simple alteration of the machine or the addition of some accessory, thus reducing "preparation time" to an almost or quite negligible quantity. But in machine-tool operations, the limits within which a machine acts, and the variety of work it will do, are not only large but indefinite. Hence the necessity for careful study of the individual job in all machine-tool operation.

15. Attention has already been drawn to the necessity for standardizing the product itself; that is, cataloguing the various parts which are common to different sizes, so that

unnecessary design is prevented. Similarly tools used for dimensioning, such as drills, taps, reamers, cutters, etc., should be catalogued, and a rule established that no dimension shall be specified, except under unavoidable circumstances, that requires special tools not thus registered in the ''book of the plant''. The same remarks apply to common small parts, such as levers, handwheels, nuts and bolts, and so forth. All these should be catalogued and not departed from in specification unless some imperative reason exists.

The object of this is, of course, to conserve effort. Though it may not take longer to sketch an odd size of some accessory than it would take to look up the standard size in the "Book of the Plant," it must not be forgotten that Design is the function that *originates activity* in the other functions. Consequently acts of design that are unnecessary lead to a whole chain of consequences that mean unnecessary effort and therefore unnecessary expense. To make a thing instead of taking it out of stock means that drawings, perhaps time studies, specifications of material, purchasing, receiving, storing and handling materials, issue of orders, job-cards and instructions, occupation of time of machines, attention of foremen, inspection, records of material, labor and expense—are all set in motion to save a few-minutes time of a draftsman. The importance of limiting the act of design to necessary things is therefore fairly obvious.

These are some of the more important directions in which the function of Design makes use of standards. In providing mechanism for making these standards available for constant reference and study we are applying practically the First Law of Effort. We are accumulating experience, using it to rectify standards, and thus applying them to our current and future work.

16. The Remuneration of Effort. It has usually been found difficult to apply the principle of special reward to the function of Design, since efficiency depends here far more on quality than on quantity. Creative work is subject to no law, and cannot be constrained or forced into grooves. In strictly routine work premiums for the avoidance of errors may be adopted. Rewards can also be offered for improvements leading to better technical efficiency of product, or to greater ease and economy in manufacture; usually however the scale of remuneration is calculated so as to take care of such events. Few examples of special reward in regard to the Function of Design are on record.

17. Application of the Third Law of Effort. As was explained in Chapter XII, the law that ''personal effectiveness must be promoted'' deals with individuals as such, and not with their functional activities. We

cannot therefore enter into a discussion of its application to any of the functions, since it does not apply uniformly throughout. Very considerable analysis would be necessary to show how, for example, "physical conditions and environment" should be set up. These would require not one but several standards, each relating to a small group of men. In the matter of quiet, the working out of a new design requires different conditions from the motion study of the work on that design. And so throughout.

Conclusion

We have now covered very briefly and cursorily the organization of the function of Design. Design sets in motion the most important activities of the plant. The more definitely we realize this, the greater will be our appreciation that this is the function of all others in which the exercise of forethought is desirable, *so that nothing shall be done, and no activity be set in motion, that is not economically necessary.* If we neglect to prescribe, with the requisite precision, such a matter as the co-ordination of parts or components—that is, of limits, fits, and tolerances—we leave the door open to subsequent waste of effort. And this waste is sure to occur. In like manner, unless we lay ourselves out to accumulate experience *systematically,* so as to form standards of practice, we shall fail to advance as much as we might; while if we do so, we shall generally be a little wiser today than we were yesterday as regards the proper method of designing our product.

TABLE XIV. PRINCIPAL APPLICATIONS OF ANALYSIS IN REGARD TO DESIGN.

1. Analysis of the machine or other product into unit parts or components.

2. Analysis of each part into process units corresponding with operation units (*e. g.,* planing, drilling, *etc.*).

3. Analysis of each process unit into two varieties of work, namely, preparation or setting, and operation.

4. Analysis of each of these varieties into its elements, namely, the several steps necessary to do the work.

5. Time study of each of these separate steps. The aggregate of time required for all the steps of preparation becomes a standard time. Similarly with time required for all the steps of operation.

6. Motion study of preparation and operation steps may be desirable, when the frequent repetition of the same work makes it remunerative.

7. In connection with (2) above, it may be found necessary to specify the use of certain tools, jigs, etc. These may, in some cases, require designing and constructing. Then their use requires analysis and study in the same manner as components.

NOTE.—Analysis of the method of operating *machines*, apart from individual items of product, is a part of Operation, *q. v.*

Chapter XIV

ORGANIZING THE FUNCTION OF EQUIPMENT

BEFORE we can undertake production we must have equipment. On the other hand, we cannot proceed to the installation of equipment before we know what our product is to be, nor can we do so satisfactorily until we have settled the volume of product that we expect to handle. Logically, therefore, in establishing a new plant, detailed designs for manufacture should have been worked out, estimates should have been prepared showing the quantity of material that it will be necessary to hold in stock, the amount of work in process that will be entailed, and the quantity of finished parts and of completed product that it is considered desirable to hold. Having obtained a quantitative idea of all these factors we shall be in a position to consider the variety and capacity of the equipment necessary for the particular problem and case with which we are concerned.

I. The Installation of Equipment

1. Application of the First Law of Effort. In all branches of equipment progress is more or less continuous. This applies not merely to operation equipment, but also to buildings and their accessory equipment of lighting, heating, ventilation and sanitation: to the plant for generating and transmitting power; to facilities for handling and storing product, and transporting it to and fro, and so forth. On *all these points,* therefore, we need to ascertain the latest practice, or in other words, the best standards, and apply this experience in selecting our equipment.

No one would willingly contemplate commencing with equipment that is inferior, since to do so would entail a serious handicap. Yet in comparatively few cases is experience systematically sought and applied on *all* the points embraced in the function. Not infrequently attention is focussed on getting the most modern and standard operative equipment, leaving the other matters to be settled haphazard. Many important matters are overlooked, particularly the fact that a plant, from the point of view of its equipment, is, or should be, a well-balanced whole. Equipment of all kinds requires proportioning, and its balanced arrangement or lay-out has a stronger bearing on efficiency than is commonly recognized. Errors made at this stage will affect adversely the fortunes of the plant through many years. Hence the importance of accumulating systematically, standardizing, and applying the best experience we can obtain at this initial stage.

2. Application of Second Law—Division of Effort. The chief elements of the problem are: (1), land and the buildings to be erected on it; (2), the equipment of such buildings with the necessary lighting, heating, ventilation and sanitation appliances; (3), the power plant and methods of transmitting power; (4), storage, handling and conveying or transporting materials; (5), operative machinery; (6), offices. In regard to each of these the different kinds of equipment service must be analyzed and apportionment made accordingly.

Thus, the first matter to be considered is the apportionment of space: the area to be devoted to each class of equipment, the size of buildings and gangways and yard space, the space required by the power plant, by stores, by shops and offices, *etc.* With a given site, the areas to be devoted to special purposes must be carefully worked out. The analysis thus made will give us a general idea of the suggested scheme of apportionment which must then be scrutinized in accordance with the next two sub-principles of the second Law of Effort.

3. Further Application of Second Law—Co-ordination of Effort. The different

parts of equipment must form a working whole. Each of them exists not for itself, but for realization of a common aim, namely, —manufacture. The capacity of the various kinds must therefore be *balanced;* power service and storage facilities must be proportioned to the demands of the volume of work expected to be handled by the operation function. Each equipment service must therefore be considered *quantitatively* so that the work of the whole may be co-ordinated. There must be no gap or overlap, *i.e.,* no department of equipment should have a smaller capacity than will be called for, and similarly it would be wasteful to have it of a larger capacity than required. Analysis of the capacity of equipment of all classes must be made, to ascertain the due proportion of each.

4. Application of Second Law (continued)—Conservation of Effort. Equipment must be arranged so that product, persons and communications follow the path of least effort. This sub-principle points out therefore the necessity of considering lay-out. Two kinds of analysis are desirable at this point. First we must trace the path of product, persons, and communications *between*

buildings, so that the arrangement of these latter in the given space may be the most efficient. Secondly, a like path must be traced *within* the various buildings, so that machines, desks, transport appliances and so forth may be arranged with the least loss of effort ensuing when work is in full swing. The result of this analysis will probably modify our first suggested scheme, and may overpower considerations based on peculiarities of site which at first seemed important.

The application of these three sub-principles should bring our proposed arrangements to a perfect form. First, we analyze the different kinds of equipment service we require, and make a rough apportionment of space accordingly. Next we consider each equipment service quantitatively, and ascertain exactly what amount of space should be devoted to each. This ensures the balancing of our equipment in its various capacities, without gap or overlap. Lastly we consider the path of least effort, and thus arrive at the precise physical arrangement of our equipment. By making these three analyses, we arrive at (1) the kind, (2) the relative quantity, and (3) the relative position of the equipment.

5. The Remaining Laws of Effort. These hardly apply to the installation of equipment, which is commonly purchased, and frequently erected by contract. We do not therefore need to consider either special as-

pects of its remuneration, or the promotion of personal efficiency in those that erect it.

II. Administrative Organization of Equipment

Equipment provides the *conditions* of manufacture. If it is of inferior quality, or badly arranged, bad conditions will be set up which will be very difficult to overcome. But the upkeep of standard conditions is also important. Equipment itself being an inert thing requires to be organized into service, such service being that of *maintaining* standard conditions.

Thus, if we have installed a poor, inefficient, inadequate power plant, good power conditions cannot be hoped for. But even if a first-class plant has been installed, it may not be administered efficiently, and thus conditions in that respect may be just as poor as if an inferior plant had been installed. The administrative side of the Function of Equipment is therefore concerned with maintaining the most favorable conditions possible for manufacture. To do this the Laws of Effort must be observed.

6. Application of the First Law of Effort. Experience as to what are standard conditions applicable to the equipment we employ should be systematically sought and applied. In regard to some departments of

equipment, standards are fairly well known. Power supply, for example, can be standardized in great detail, and any departure from standard working observed at once. Other equipment standards are those of heating, standardized by the thermometer; of maintenance, standardized by freedom from breakdown; of cleanliness, standardized by very simple inspection; of transporting and conveying service, standardized by absence of delays due to work being held up between transport points.

Few plants have begun to look at equipment services as capable of standardization in this way. But as the proper working of equipment and the services it performs are really controlling conditions in most instances, the importance of doing so cannot be doubted. It is the more important because most of the inefficiencies of equipment are insidious and unperceived, unless we look specially for them and keep a standard of performance in view. They do not bring production to a stop, but they slacken its pace. They do not affect direct cost of jobs, but only affect burden and cause waste of capacity to produce. Therefore, the inefficiencies of equipment are not spectacular, but only very injurious.

7. Application of the Second Law—Division of Effort. Division of Effort in regard to administration of equipment has relation to the organization of the various equipment

services in units of simplest skill, special men being assigned as far as possible to special duties, either individually or in subgroups, as care of belts and transmission appliances, of motors, of the different sections of power service—lighting, heating, ventilation, *etc.* All the various services expected of equipment should be *analyzed,* so as to show the different classes of effort necessary, such as firemen and stokers, engineers, painters, carpenters, electricians, repair mechanics, cranemen, elevator and conveyor operators, *etc.*

8. Application of the Second Law (continued)—Coördination of Effort. The different classes of effort required in the function of Equipment having been determined by careful analysis, the problem must be studied *quantitatively.* How many men of each class will be required, from the works engineer and his assistants down to the shop sweepers? Duties will be so allotted that the due proportion of each equipment service can be steadily maintained without gap or overlap. No service should be neglected, or its care left to chance. Everything, even periodical and occasional jobs, should be

definitely included in the scheme, so that every effort that goes to maintain conditions may be co-ordinated.

9. APPLICATION OF THE SECOND LAW (CONTINUED)—CONSERVATION OF EFFORT. Equipment services should be so planned that they are continuous and not spasmodic. The golden rules of equipment service should be (1) that prevention is better than cure, (2) that a stitch in time saves nine. The effort concerned in maintaining conditions can be most readily conserved by *not letting things happen.*

The money value of even, unvaried, uniform equipment service is enormous, although not by any means as much appreciated as it should be. Starving such services is an easy way of showing bookkeeping economies, but of two plants one of which has its cost of equipment service 50 per cent higher than the other, the money saving may be represented by just those uneven, broken conditions of equipment service that pull down the whole efficiency of manufacturing without anyone being able to lay a finger on the exact place where inefficiency exists.

10. APPLICATION OF THE SECOND LAW (CONTINUED)—REMUNERATION OF EFFORT. There is without doubt a good field for special remuneration in the field of equipment administration. It divides naturally into groups,

each of which is a sub-function almost independent of the others. Such sub-functions are the power group, the building-maintenance group, the lighting group, the various groups of repairmen, the cleaners and so forth. There seems a good opportunity here to apply the principle of special remuneration, *based on the maintenance of uniformity in conditions*. Probably group-incentive is also indicated.

Such Remuneration would naturally consist of a bonus given for maximum efficiency being attained in keeping equipment services up to standard. Deductions would be made for failure, in proportion to its gravity and extent. A high degree of interest in the work of the function as a whole, or at least in the more closely associated work of the sub-groups, should be developable by carefully thought out special Remuneration.

11. Application of the Third Law. It is worth noting that the function of equipment is the special engine by aid of which the first sub-principle of this law is set in motion, namely, that ''Good physical conditions and environment should be maintained''. As already stated, the Third Law reaches its practical application not in functional but in individual activity.

Conclusion

The selection and installation of equipment has a separate set of efficiencies from its current working or administration. Careful selection and arrangement according to the Laws of Effort is essential unless the plant is to be burdened, more or less permanently, with inefficient conditions, since it is the function of equipment to *provide* suitable conditions for production in every department.

Similarly, when the equipment has been installed, a large part of the conditions it sets up are made effective only by efficient administration. The administrative side of equipment deals with *maintaining* suitable conditions. However good the equipment and however skilfully it may have been arranged in the first instance, the realizable efficiency will depend on whether the Laws of Effort are being observed in running it. Some of the principal ways in which the laws are applicable have been indicated.

Both in installation and administration of equipment, there are standards to be ascertained, and lived up to. These standards are also subject to rectification and improvement from time to time. When both the original standards of installation and the current standards of administration are high, the function will be working at its best. If either of them has been organized without reference to standards, efficiency is a matter of luck and will probably be much lower than it should be.

TABLE XV. PRINCIPAL APPLICATIONS OF ANALYSIS IN REGARD TO EQUIPMENT.

1. Analysis of the proposed product, with a view to determine what kind of equipment must be provided to handle the volume of work expected.
2. Quantitative analysis of the different kinds of equipment service that will be required, under the principal divisions of:—power plant; storage, handling and conveying facilities; operation equipment; offices; and the buildings that will be required to house these arrangements.
3. Determination of space allotment required for buildings, yards, offices and machinery, based on (2).
4. Analysis of route to be followed by product, persons and communications *between* departments.
5. Analysis of route to be followed by product, persons and communications *within* departments or shops.
6. Arrangement of buildings, yards, offices and machinery to the best advantage in regard to the space available, based on (4) and (5).

Chapter XV

ORGANIZING THE FUNCTION OF OPERATION

IT may be well to consider at this stage the organization of the function of Operation. Though in establishing a plant, Design (that is, the detailed determination and specification of what we intend to do) must come first, and consideration of Equipment next, when the plant is actually running Design and Operation may be considered a pair of functions that are closely inter-related, Comparison and Control another such pair, while Equipment is the basic function which provides conditions for all these activities. We shall therefore consider the function of Operation here, leaving Comparison and Control to later chapters.

Operation is that function which has to do with the application of machine processes, trades, and skills to effect changes in the status of materials in accordance with the specifications of Design.

Operation is the *synthesis* of a number of separate processes, trades, and skills, and usually, but not always, these are exercised through the operation of machines. In most industries machines occupy nearly the whole field of Operation, such hand skill as remains being usually occupied in giving greater finish to product than machines can be made to give. Each distinct skill or machine process is a unit of operation. The efficiency of Operation is measured by its success in applying these skills to product so as to carry out the specifications of design *with the least expenditure of effort.*

Operation, therefore, is the actual technical work of cutting, twisting, spinning, weaving, heating, mixing, assembling, *etc.*, as performed on the material to change its status. It does not include anything other than this. Therefore it does not include maintenance (which belongs to Equipment), inspection (which belongs to Comparison), or handling of product (which belongs to Control), except that portion of handling which comprises placing the material in place on the machine and removing it from the machine after the work which actually constitutes operation is performed on it.

1. Applying the First Law of Effort. The systematic accumulation, standardization and application of experience with regard to operation has two sides, one of which has a purely technical application, and the other an administrative application. As has been said in a previous chapter, the *technical* efficiency of operation lies outside the science of management. It may be a matter of chemistry, or of physics, or of mechanics, or of a combination of these sciences, but it is not a part of the science of administration. If it were, then every separate little plant would have to have a separate science of management for its own, which is obviously not the case.

While therefore the first Law of Effort holds good in regard to technical progress, we have not to consider that application here. We do not need to consider the different methods of accumulating and standardizing technical experience that might be open, for instance, to a maker of microscopes or to a maker of woolen fabrics. A new dye formula, a new alloy mixture, a new special machine, a new kind of material—all these are improvements on the technical side of production, but except in so far as they may modify equipment, and change the order and nature of operation units, they have nothing to do with management as such.

What then are the standards to be set up in regard to Operation? Obviously they will be *Operation* standards, the assumption being implied that the processes adopted in the plant are already technically correct. But with a given technical process there is a whole range of possibilities in its carrying out. It may be carried out with the minimum of effort, or on the other hand very inefficiently.

The standards which we must seek, then, are those of efficiency in applying current accepted technical processes to product. We have also to consider the working of the Operation Function as a whole, a thing that we are unable to do in regard to any other Function, but which can be done here because we have a convenient measure of efficiency. In other words, we have an easily applied standard.

Operation standards are then of two kinds, one relating to the efficiency of individual operation units, the other relating to the total productive capacity of the plant.

As regards the first of these it is really surprising how little many manufacturers know, and are content to know, about the capacity, duty, demands, and life history of their machines—the pivotal point on which their whole industry turns. Ask a question in almost any shop about a particular machine, and, in nine cases out of ten, if there is any intelligible answer at all, it will be an empirical one; some one, single, unrelated fact, instead of a range of facts with defined maxima and minima. If, for example, one inquires about the capacity, the answer, as likely as not, will be, "We have gotten as many as 50 of our No. 3 collars off that machine in an hour". If one asks about the power consumption, the answer, "Oh! about 5 horse power", will frequently be the merest guess, based on what someone once told someone else about a machine something like the one in question, but by another maker. The question, "What does it cost an hour for the productive capacity of the machine?" will be met by an amazed stare, as if one had asked, "What's the cost of a sunset?" It is only within recent years that it is beginning to be understood that there is probably a range of ratio or mathematical relations between feeds, speeds, and cuts in ordinary machine tools.

Nor has the recent tendency to rely almost wholly on the analytical method greatly helped to develop the central importance of knowing everything about the machine. It has rather had an opposite effect. It has tended to the neglect of the broad and general problems which hold innumerable detailed problems in their solution, and focussed attention on the infinitely little, on the principle, doubtless, that "mony mickles make a muckle". It has called attention away from the machine, to devote all its energies to individual items of product. In some industries this point of view is useful and even necessary, but even here the range of capacity of the machines needs much more attention than it commonly receives.

To throw further light on this question, let us glance at the advantages we might expect to realize by indicating machine processes in terms of the capacity of the machine. First, for each type of machine there would be an average ratio between actual machining time and preparation time. It has already been pointed out that machines earn only on their operation time (*i. e.,* when actually cutting, spinning, *etc.*); consequently if a quick method of machining (as, for example, grouping a number of small parts on the bed of a large planer) is accompanied by slow methods of chucking and securing the work, it may be (and in an actual case was found to be) economically inferior for doing the work on a smaller milling machine, under conditions that permitted chucking of one part while the other was under the tool, and consequent *continuous operation* of the machine.

The principle of the conservation of effort implies that to hold a machine idle during preparation is a dead loss, and consequently that the shortening of setting operations is much more important than is often realized.

The present point, is, however, that for each machine there will be maximum and minimum ratios of preparation time to machine time, which are economically reasonable, and if this maximum is found to be exceeded on any job, it needs attention.

In the same way, for each machine, and for all classes of work done in any one kind of material on it, there will be a maximum and minimum machining time per unit area. Thus in 1889 it was considered that planing a large continuous surface of cast iron required from three to five hours per superficial foot. The turning of plain rolled shafting was reckoned at thirty minutes per foot of finished surface.

Now if this view of a machine's "duty" were developed, and if attention were given to minutely determining the capacity of machines for the different classes of work in vogue, and if this capacity were expressed first in terms of operation time per unit of surface, and in ratio of preparation time to operation time, we should be in possession of knowledge capable of being co-ordinated into something worth having. This is the direction in which time study and analysis should be turned, because the results will be capable of comparison and grading, and would eventually lead to something like real standardization of machine operations.

Also if this were accomplished, the labor price, being associated with definite standards of size and area, would reach common ground, and lose the air of a stop-watch inquisition into the skill of the man, which some methods of fixing prices now have. Some approach to a standard and universal price list for labor, depending on recognizable units, would be possible. That such a condition is ultimately attainable is certain, because though *work* is infinite in variety, the number of types of *machine* is limited, and not beyond practical means to investigate. Machine tools, being most "universal" in their range, are the most difficult of all.

The second kind of operation standard has relation to the total productive capacity of the plant. With a given equipment it is obvious that there is a point beyond which more output cannot be obtained by any means. The practicable normal maximum of output will probably be somewhat lower than this theoretical maximum, and may form our standard of operation capacity. As all the other functions exist for the ultimate purpose of operation, it follows that all their expense falls ultimately on Operation,* and is chargeable on the product "at the tool point". We are therefore able to express the total productive capacity of the plant in money value, or to put it another way, we find that our "capacity to produce" costs money, and may be standardized in dollars rather than in any other kind of standard notation.

In contemplating our shop full of machines, and having arrived at a clear understanding of the fact that every single hour of their "capacity to produce" costs money, it would easily be deduced that only when they were actually cutting were they earning that money. From this it is but a step to realize the importance, not only of keeping them at work, but of recording exactly their periods of work and idleness. This idea, so likely to occur to anyone who approaches the problem without being influenced by current methods, is at once simple and obvious, as well as far-reaching in its importance.

* See Chapter VIII; also the author's "Production Factors".

For all that, it is carefully and persistently ignored in most shops. It is because the average factory has "just growed," and has only recently begun to feel the need for a corporate mind, that no study, and no provision for study, is made of the periods in which groups of machines and individual machines are "eating their heads off". Yet it is obviously the very first thing we ought to know all about. To set about doing so is to gather very pertinent knowledge.

Such knowledge is, of course, of no use as a collection of isolated facts. It requires to be co-ordinated with something else. To know that No. 26 grinder has been stopped two hours in the middle of the day may or may not prove to be useful; but to know what proportion of the working day No. 26 grinder is idle, *on the average,* may be the starting point of interesting discoveries. The How, When and Why of its periods of idleness provides a mastery of facts that can easily become very valuable.

To illustrate a few of the ways in which a close scrutiny of the periods of idleness may be useful, we may consider the machine that "is not much used". It is an old friend. Physically we ignore it, as we pass by. But its reproachful presence, day after day, week after week, on our "idle-time" chart, will possibly lead to a job being schemed out suitable for it. Again, irregular duty of some large machine, totalling up possibly into a considerable loss, may be traced to inadequate crane service. A machine that suddenly develops a higher average of idle time may prove to be the victim of a new class of work, for which chucking arrangements are capable of improvement. Instances like these might be multiplied indefinitely.

Really, when one regards the matter squarely, it becomes amazing that the control of idle machine time is not the very first thought of the management. But for an accidental evolution away from the idea, it certainly would have become so long since. Developing things in their logical order, anew from the beginning, it appears obvious that one of the first items of experience to be accumulated and systematically used will be this very one of idle time.

The employment history of employees is not infrequently quite carefully compiled, yet the life history of machines is just as commonly entirely neglected. One of the items of this life history—the daily, monthly, and yearly tale of its idleness, and consequent failure to fully meet the burden of its cost of "capacity to produce"—we have just discussed. Another item is its cost for repairs. If the truth were always known about the individual cost of repairs of every machine in the plant, many accessions to the scrap heap would take place, with substantial benefit to efficient production. The two items taken together—loss of duty through idle time, and high cost of repairs—would cause many superintendents' hair to stand on end, when they scrutinized the life history of the productive machines by which they were trying to make money. Ignorance is bliss, but it rarely pays high dividends.

It may be mentioned here, though the matter is rather one of accounting, that the life history of the machine should include its capital value, its yearly depreciation, expectation of life, and similar data, such complete history being specially valuable in prompt settlement of fire losses, for inventories, and so forth.

As the years pass, such a life history becomes more and more useful. Most machines have a critical age at which they have really outlived their efficiency, and the falling (depreciated) value, the rising cost of repairs, and the idle time, taken together, tell the story with an accuracy that no judgment based on superficial appearances can pretend to rival.

In determining the productive capacity of a plant, the first thing is to know, exhaustively, what each machine *will do.* This seems obvious, yet in practice very few people approach the problem in that way. In the case of a simple automatic machine, a steam stamp, for example, punching out blanks from continuous strips of metal (such as the metal parts of umbrellas) the productive capacity of the machine contains very few factors. With a uniform quality and thickness of material, production is limited only by the rate of feed; that is, the number of times the plunger can rise and fall per minute, making a clear cut stamping. The only deductions necessary are those due (1) to changing dies for sharpening, or alteration of pattern, and (2) to replenishing the supply of strip. This latter is usually negligible.

With the "Production Factor" method of ascertaining hourly machine cost, the cost and profit making price of product of such a machine can be forecast with minute accuracy.

2. Application of the Second Law. Division of Effort. The degree of division of effort in operation is conditioned by the state of development of the particular industry, and also, in many cases, by the volume of output. Units of operation are fixed

and set in some industries, and cannot be varied save by new invention. But the tendency of division of effort in operation is very clear. It is towards developing units of operation, each requiring simple skill, and towards the elimination of units requiring high-grade skill. In any new plant, the question of the degree of division to which operation is to be carried is a matter of grave consideration. Many of the advantages to be gained in competition with established businesses may be based on setting up a somewhat greater degree of division of operation into simpler units than has hitherto been customary in the particular industry.

3. SECOND LAW OF EFFORT (CONTINUED). CO-ORDINATION OF EFFORT. Whatever the degree of division, Operation must necessarily be a complete synthesis, without gap or overlap in the series of processes. In replacing a unit operation by two or more requiring simpler skill, this principle needs observing —nothing must be lost in the division. What is sometimes lost is complete co-ordination; the new processes do not perhaps cover precisely the same ground as the old one, but require complementary hand work to effect

the former finish or the former accuracy. Real gap is rare in operation as its presence, if marked, would bring production to a stop. In some industries, however, notably machine shops, something like overlap occurs, in that several types of machine (*e. g.*, planers and milling machines) have closely similar operative effect. In such cases a customary use for each should be set up as far as possible, even when either may be used indifferently on certain work. Imperfect machine work, requiring expensive hand fitting when assembling, is the most common instance of poor co-ordination in operation. This is quite apart from similar want of coordination that may be caused by neglect to specify limits and fits in connection with the Design of the parts. This last is gap in Design, not in Operation.

4. Second Law of Effort (continued)—Conservation of Effort. The application of this principle has been fairly covered above in our discussion of standards of operation. Where it is possible to do so, analysis of machine operation rather than of the product should be the end to which time study and motion study should be directed. The reduction of preparation time to a minimum

should be sought, since anything that holds back the machine from being actually engaged on altering the status of material is a dead loss of productive capacity. The study of capacity of machines; what they will do (not merely what it has been customary to expect from them); how far they may be speeded; how long, on the average, they are idle; how far they are subjected to stoppages and why; how far preparation time can be shortened; and similar matters, are the true sphere of conservation of effort in regard to operation. Further, the aggregate of answers to these questions will show the way to conserve the "capacity to produce" of the Operation function as a whole, and to eliminate idle time to a considerable extent.

A corollary of this principle establishes a rule, frequently neglected, namely, that all Effort classed and paid for as operative should be focussed on operation. Workmen and operation officials should not be made into clerks. Amongst other things it may be pointed out that the foreman represents, more than anything else, the *technical* efficiency of operation. The analytical school of management has had dreams of abolishing the foreman, but this is simply because, having relieved him of some of his administrative duties, they did not observe his place in the synthesis of production. He is the repository of technical experience at the fighting line, quite apart from his administrative duties, be these heavy or light.

5. SECOND LAW OF EFFORT (CONTINUED)—REMUNERATION OF EFFORT. Generally speaking, the field for remuneration of effort in Operation is the largest of all, and it has hitherto held most of the attention of investigators. Its special feature is reward for turning out the largest amount of product with the least application of effort, *i. e.*, in the shortest time. It is the merit of the analytical school of management that it has discovered that the operative alone can only go a short way towards bringing about maximum production. The present study of the subject, it is hoped, also throws light on this subject, by showing what other clearly definable Functions than that of operation are engaged in the synthesis of production, and that their efficient functioning is a matter quite apart from anything the workman can do.

The subject of remuneration in Operation is a large one and has already a considerable and important literature of its own. In the appendix to this book some aspects of it have been discussed. It is therefore only necessary to say here that in various industries different bases for special remuneration may be employed. In the general run of plants premiums or bonuses are based on doing standard quality of work in least time, and in some cases this principle is extended by offering supervisors a bonus based on the bonus earnings of their operatives. Another class of bonus is based on the reduction of wastes, or economy in the use of materials, when these elements of efficiency lie within the more or less careful exercise of skill of the operative. Yet another class is based on the continuous operation of machines, when the latter is dependent on the skill or attention of the workman. Other special rewards in regard to Operation are based on suggestions for improvement in processes, machines or methods, and for means of reducing wastes.

6. Third Law of Effort. The remarks on this law with regard to the other functions apply to Operation also. As, however, the operating force usually outnumbers that of all the other functions put together, its application to the operatives should be most carefully considered, and each of its provisions put into force as far as possible, so as

to create a satisfactory atmosphere among the human factors of this function.

TABLE XVI. PRINCIPAL APPLICATIONS OF ANALYSIS IN REGARD TO OPERATION.

1. Analysis of the different skills, trades, callings and machine processes into operation units. (Note.—Units of design must correspond exactly with these operation units.)
2. Analysis of the scope or range of each machine, where it is capable of performing more than one operation, or can be varied in capacity, speed, feed, *etc.*
3. Analysis, by means of motion study, of the various steps of feeding material to and operating each machine. This is the most valuable field for the employment of motion study, inasmuch as the new standards thus set up can be fostered into new habit on the part of the operator.
4. Analysis of the productive capacity of each machine or "production center", so that a "loading standard" can be set up. The average amount of product turned out in a given period can then be calculated and made use of in arranging sequence of orders and making promises of delivery.
5. Analysis of the "total effective production capacity" of the plant, based on number of working hours in a given period, so that "capacity used" can be distinguished from "capacity wasted", and thus a measure of the general efficiency of production in each shop set up.

NOTE.—The analysis of individual items of product by time or motion study is a part of Design, *q. v.*

Chapter XVI

ORGANIZING THE FUNCTION OF COMPARISON

EXECUTIVE success depends upon three elements: (1) recognition of what facts are truly significant; (2) accurate record and convenient presentation of these facts; (3) judicious action based on study of the facts. Executive success is therefore largely dependent on the function of Comparison.

Modern management is coming more and more to be based on measurement. Whilst the effectiveness of control depends upon the personality of the executive, it is evident that an accurate knowledge of the nature and extent of the changes set up by Production is necessary to every executive, if wise decisions and judicious control are to result. Many firms have had reason to regret decisions taken on the faith of hastily compiled "statements", though prepared by the officials without any intention to deceive, but on the contrary with entire faith in their accuracy and confidence in their representative character.

It may not be evident at first sight that the basis of Comparison is for the most part accounting. This is because few people understand what modern accounting really is. Popularly it is supposed to be concerned with the verification of cash and balance sheets, but this is only one branch of the subject. Accounting *in its broadest sense is the practical application of the science of quantities. It measures and records, not merely cash, but every kind of quantity that is concerned in the processes of a business.* It measures and records these quantities by means of general laws which are independent of the kind of quantities involved, and proves the accuracy of its measurements by recognizing that every change in a quantity is necessarily merely one of a series of changes, all of which form dependent sequences.

Failure to realize increased net profit which sometimes attends reorganizations is frequently due to the fact that such work has been undertaken without the safeguard of analytical accounting. It is not very difficult to show savings in any one quantity—say, for example, direct labor—and as a matter of fact it is the easiest thing in the world to deceive oneself as to the effect of changes in method and routine unless results are controlled and safeguarded by a thoroughly modern accounting system, designed and installed by experts possessing both the necessary technical knowledge of the principles of management, and of the principles as well as the everyday practice of accounting.

1. Application of the First Law. While all departments of the function of Compari-

son employ methods which have already been developed to a high degree of precision, the internal organization of no other function, save that of Control, needs such careful selection of means and such careful planning out of aims or ends, if efficient results are to be found.

The work of the Function is the accurate determination and record of significant Quantities. The difficulty of the problem lies in the fact that shrewd analysis is frequently necessary to determine what is, or is not, a quantity sufficiently significant to be worthy of separate measurement. The general cloud under which the question of "Burden" rests, and the vague ideas as to its significance held by many manufacturers, are examples of the kind of problem met with by the expert. Here it is not a question of mere subdivision of items—an operation frequently mistaken for analysis by those unfamiliar with scientific accounting—but of so grouping ultimate details that some significance can be extracted from the interplay of the various groups, and their rise and fall.

The selection and synthesis of unit quantities is, in fact, no fit work for the amateur, even though closely in touch with the technics of his particular manufacture. So far from being able to apply the necessary analysis and synthesis to their own business to effect control, not a few manufacturers do not even know what data they should have before them to effect that control. And between knowing what they are and getting them is frequently a long path. It is not infrequently the case that the constructive accountant has to give considerable study in order to indicate to the executive just what data he ought to have, and why he ought to have them.

The reason why the measurement of quantities needs to be conducted with considerable exactness is that in a manufacturing business every change in the value or amount of a quantity is related to change in one or more other quantities. Unless precautions are taken to record these changes in such a form that they can be proven, one by the other, the records become mere inaccurate memoranda, and action based on such is frequently discovered subsequently to have been a grave mistake. Even in regard to such purely technical matters as the efficiency of particular types of machines, properly designed systems of accounting give the most valuable assistance in determining just what types should be purchased when extensions are in hand.

As an example of the selection and use of *significant* data, reference may be made to the case of a business on the verge of bankruptcy that had been losing money for several successive years. This was not only saved from breaking up, but actually transformed its losses into a profit of some $100,000 a year, entirely through effective control brought about by modern analytical accounting. It was found that some lines were reasonably profitable, while others believed to form the staple of the business were being sold for less than they *really* cost, at that time. Once these facts were made known to and proven to the satisfaction of the directors of this concern, they were enabled to make decisions without fear of mistakes, and very soon took measures to eliminate the losses and push the profitable lines of product. Such rectifications are no uncommon experience where modern methods of control are adopted.

The accumulation, standardization and application of experience in regard to Comparison is, at the present day, a task which is almost wholly a professional one. It has a large literature and forms a complete study in itself. It is therefore obvious that it cannot be condensed into a few happy phrases, because each plant furnishes different problems of a much more obscure character than is the case with either of the functions already discussed.

2. APPLICATION OF THE SECOND LAW. DIVISION OF EFFORT. Units of comparison must be set up. Unless we have similar units of quantity and similar notations one thing cannot be compared with another. These units are of two kinds, those connected with the chemical and physical status of material, and those dealing with time, quantity, number and value.

The first class includes the testing of materials for comparison with previously determined requirements as set out in standard specifications. It also includes the Inspection of product, *i. e.*—its comparison with previously set requirements of finish, limits and dimensions. The measurement of power as delivered to various departments day by day—an important record very frequently neglected; the recording of shop temperature; pyrometric records in certain kinds of furnaces; recording tachometers for comparing shaft speeds where uniform speed is important—all these are examples of physical comparisons, to which in most cases *no money values can be assigned,* and therefore they are not controlled or verified in any way by accounting methods.

The second class comprises comparison of quantities that enter into Operation, *e. g.*—the measurement of labor time and machine time; the division of the latter into time consumed in setting and in cutting; the analysis of machine time into that utilized on work, and that falling into the category of "wasted capacity". Further, this class comprises the record of labor and machine time on product at every one of the successive stages it reaches, and particularly the influence of doing the same work in different ways and on different machines. The records in this class are also always expressed in money values as well as in measured time, and so fall under the control of the accounting system and are proven by the latter. Finally it comprises the record of quantities of product, whether expressed by number or weight.

In the second class is also included the measurement of the indirect services and production factors which are maintained for the purpose of keeping the machines at work. Though these rest primarily on the measurement of quantities, such as land area, building floor space, horse power, and so forth, they differ from the first class of comparisons in that money values are always connected with them, and consequently that they can be rigorously checked, controlled, and proved by the general accounting system.*

One of the things that strike us in most businesses when we study the connected series of effort that makes up the full activity of a plant is the presence of wastes. These may occur in the department of organization, as in too high cost of power, or of transport; or in operation, as in the case where material is spoiled and fails to pass inspection. In

* See Chapter VIII.

some businesses, of course, quite a high percentage of wasted effort is inseparable from the nature of the operations, as in some classes of foundry work. The recording of wastes in such a way that their causes can be analyzed and as far as possible removed is sometimes a matter of difficulty, but is always a most desirable and important feature, too much overlooked. Generally speaking, records of wastes are worthless if not tied into the general accounting system of the plant. It is only recognizing the limitations of fallible human nature to say that they will always be concealed when possible. Consequently the tally of wastes must be proven by some other means than an unverified statement.

3. THE SECOND LAW OF EFFORT (CONTINUED). CO-ORDINATION OF EFFORT. The practical result of applying the principle of division of effort to Comparison is that we set up a series of isolated comparison units or "transactions", each of which forms a standard with which something has to be compared. Necessarily each transaction has definite limits, or we could not record it. Now the principle of co-ordination demands that all these unit transactions taken together shall cover the whole of the activities of the plant without "gap or overlap". The sphere of each unit must be so delimited that it leaves nothing to be recorded between itself and the next unit. Neither must any

transaction be recorded twice—one record should cover all information required about that transaction.

This does not imply that exceeding minuteness in recording is necessary. Some kinds of transaction can be dealt with broadly, others in great detail, but even in the former case there must be nothing left out between one such broad grouping and the next. This is one of the pitfalls of amateur organizers. Either they insist on the most minute records, without giving adequate exercise to their sense of proportion, or they endeavor to economize work by leaving out matters which are really significant.

Further, complete co-ordination is the only path to results which, when presented monthly or periodically, are significant and intelligible. One test of this, *and an imperative condition of success,* though it is not entirely exhaustive, is that all figures that deal with money values should be provable and proved with the financial books of the concern. Figures that do not do this are worthless and dangerous, but even when they do, it does not follow that co-ordination is complete for all purposes for which the records may be required. This can be ensured by only expert analysis, on the one hand, and by practical experience on the other.

4. Second Law of Effort (continued). Conservation of Effort. Having set up units of comparison in regard to all significant transactions and having made sure that they are so co-ordinated as to form a com-

plete synthesis without ''gap or overlap'', it becomes necessary as the next step to ensure that the amount of effort involved in the observation, record, presentation and comparison of the resulting data is at a minimum. The shortest path from the unit fact to the final statistics must be sought. Mechanical aids should be used where possible, but judiciously.

To effect this conservation of effort very careful scrutiny of the whole system of statistics is requisite. In many plants, where old-fashioned methods are in vogue, endless copying from one record to another goes on. Large tabular statements are prepared, full of detail that is not only unnecessary, but is an obstacle to the quick summation and seizing of the significance of the figures. The facility with which voluminous statistics can be prepared by mechanical aids has also given rise to much unnecessary work, and, instead of fitting the machine to the work, the work is too often arranged to suit the range of action of some machine. The principle that no data are worth recording unless they are to be *compared* with something, either a standard arising out of the experience of the past, or a contemplated repetition of the same work in the future, is frequently overlooked. This is simple waste of effort. Simplicity of "system" is indicated by the principle of conservation of effort in regard to comparison, and this does not mean an *insufficient* system, but one in which every effort has a definite economic value in its contribution to the system of Comparison as a whole.

5. Second Law of Effort (continued). Remuneration of Effort. Very little attempt has been made, so far, to apply special reward to those engaged in the function of Comparison. The lines along which this development should take place are, however, not difficult to determine. Efficiency in comparison is (as regards its routine work, and quite apart from the structure of the system employed) almost wholly dependent on two factors—accuracy and promptness. The first of these applies, of course, not only to the first record, the observation of unit facts, but also to all subsequent handling of the data. Both the technical and the clerical work of comparison is dependent for its value on accuracy. Similarly, data which are only available for study and discussion long after the facts on which they are based have passed out of the memory of the individuals concerned in the transactions are of exceedingly little value compared with data presented as it were red-hot on the heels of the transaction immediately after its occurrence.

In working out methods of special remuneration for this function, a natural standard of 100 per cent accuracy can, of course, be taken. This theoretical perfection can have a definite amount of bonus attached to it, with deductions for failure to reach standard. In regard to promptness, however, no such natural standard can be found. It is not, in fact, necessary that all classes of transaction should be worked up into final data with the same amount of urgency. In proportion as transactions are numerous and small, as for example the issue of stores, or the recording of men's time on jobs, the urgency is greater, since the memory of such transactions passes after the lapse of a few days in most cases. If inquiry is to be made, therefore, it can be made with a fair chance of success only if made within a day or so at latest. The setting up of standards for promptness must therefore be carefully worked out, with all the circumstances of each class of transaction taken into consideration.

In this function, as in the others, it may be worth while to offer prizes for suggestions tending to improve routine, or for pointing out causes of inaccuracy in methods of collecting unit information at its source.

6. Third Law of Effort. Among the applications of this Law to the personnel of the Comparison function, the question of proper physical conditions and surroundings appropriate to each official's work should have special consideration. Vocational fitness has also an important bearing, the study of qualifications for the different kinds of work grouped under Comparison being little advanced at the present moment; yet to a

greater extent than in any function that we have hitherto discussed, except that of Design, a good deal of success depends on having precisely the right type of individuality engaged in observing and recording data, a type which is probably quite different from that necessary for its routine working up into final form.

TABLE XVII. PRINCIPAL APPLICATIONS OF ANALYSIS IN REGARD TO COMPARISON.

1. Analysis of operation sequences, to determine at what points inspection is necessary.
2. Analysis of all accessory services (power, *etc.*) to determine the points at which observation and record are necessary.
3. Analysis of operation sequences, to determine between which points costs should be taken out.
4. Analysis of the different sources of wastes, to determine at what points they should be observed and recorded.
5. Analysis of the material situation, to determine what varieties of material should be subjected to chemical examination or physical inspection on receipt in stores.
6. Analysis of burden to determine how it should be charged against production capacity.

Chapter XVII

ORGANIZING THE FUNCTION OF CONTROL

THE function of Control must be considered from two sides, installation and administration. Installation provides the scheme of duties; administration provides the men and the action. As has been stated in a former chapter, Control is, popularly speaking, the function of the "boss" and is the last function remaining, when, in the successive devolutions of functions during the rise of an industry to modern complexity, all the other functions have been shed.

Installation of Control

Material and equipment being perfectly inert, and giving rise to no change by themselves, it follows that production is a result of the actions of living persons. In practice the duties of such persons have to be organized according to a definite scheme, so that each has certain specified work to attend to. It is obvious that such allotment of duties will be affected by the Laws of Effort, and will need standardizing, dividing, co-ordinating, conserving, etc. The planning of such a scheme of duties is the "installation" of Control.

The planning of duties *within* each function is, of course, as much a part of Control as any other. But we do not need to consider it here, for the reason that all its problems have been discussed under the head of each function already. This leaves us with the necessity for planning the relations *between* the functions, and of those duties peculiar to the function of Control which are not included in any other function. In other words Control plans all duties whatever, but as whole groups of such duties are handed over to other functions to perform, we need not consider them over again.

The aim of Control is the setting of things in motion. We may picture to ourselves all our other functions fully organized and waiting to begin—Designers and production men ready for work; equipment installed, engineers ready, repairmen organized; operation machines installed and men standing at them; comparison methods worked out and the staff at their posts—but there is still needed something to set them all in motion.

This thing wanted is the will of the boss, expressed in orders. Practically this is given effect in modern plants, not by a single man who gives the word to ''go'', but by a more or less elaborate organization, which makes it its special business to attend to the regular and systematic issue, dissection and distribution of Orders. The Installation of Control is the preparation of the scheme of this organization. It establishes the mechanism of the Function.

Administration of Control

We have then to consider this mechanism at work. The personnel being installed, each member of it with his specified range of duties, the issue of orders begins. But as the work carried out in response to the issue of orders is not always exactly as intended, it becomes part of the administrative function of Control to observe failures, study their reasons, and set in motion new orders, instruction, or training to prevent these irregularities from recurring as far as is possible. While these two aspects of Control are necessarily quite distinct, for installation must be complete before administration can begin, nevertheless it may be convenient to consider both aspects together—both being equally subject to the same Laws of Effort.

1. Applying the First Law of Effort. What standard methods of control exist? To deal with this question in detail would require a considerable volume. Systems of control are, at present, the battle-ground of the different schools of management, and this ground is occupied in force at the present time by the analytical school, from whose efforts has arisen (to give justice its due) much of the awakening that has taken place of late years in regard to the science of management. As the subject has, like Comparison, a large and increasing literature of its own, at this stage we can only recommend its study to those who desire to accumulate, standardize, and apply experience with regard to it. For some years to come, however, it seems likely as in the case of Comparison, and for the same reason, that the study and application of standard methods of Control will be the work of the professional expert, rather than of the manufacturer himself.

2. Second Law of Effort. Division, Coordination and Conservation of Effort. In regard to the installation of Control we must

first effect an analysis of the various duties to be performed, and set up units, each demanding the simplest skill possible. Each duty should represent a definite grade of qualification. Each duty should be precisely defined so that no ambiguity exists as to its range.

Secondly, we must carefully examine this rough scheme of duties in the light of Co-ordination. Have they been so arranged that no "gap or overlap" exists? No jurisdiction should overlap. No man should be expected to serve two masters. The spheres of duty must exactly join so that no item of work is left outside, to be performed by anybody who thinks of it, or neglected because someone thought someone else was attending to it.

Again, the question of co-ordinating the work of individuals by means of *communication* must be worked out. What duties require that their incumbents should be in direct touch with each other? Where should duties be co-ordinated by means of regular "conferences" or meetings? How far should "staff" assistance (*i. e.,* the assistance of specialists) be available for certain men, and what degree of authority should such staff members have?—All these will require discussion and settlement after the general scheme of duties has been roughed out. Finally, each duty must be considered in the light of conservation—that is, each must be considered quantitatively. What amount of effort is involved in each duty? What force will be demanded to carry out each kind of work? This must not be too small nor too great. Red tape must be eliminated by carefully scrutinizing each duty, and observing its actual necessity, and asking whether the effect expected cannot be brought about in some simpler way. Considerable experience with a variety of control systems is necessary to answer most of these questions effectively.

So far we have said nothing about the *nature* of the duties. We have merely spoken of certain essential treatment of each duty, whatever its nature. We have now to consider the duties concretely, and this can be best done by considering Control from the administrative side. For it is precisely here that systems diverge. In other words, the various duties performed by Control are not so very different under old and new systems of management, but they are differently grouped. It is not so much that new duties have been invented, but that new relations have been suggested for them. This must be discussed at some length.

No problem in management requires expert handling so urgently as this if, on the one hand, oppressively complex systems of control and, on the other, loose methods involving friction, delays, loss and recriminations are to be avoided. It is necessary, therefore, to try to see very clearly what the essential elements really are.

Two Antagonistic Elements

The problem owes its difficulty to its containing two antagonistic elements, which must be reconciled and adjusted to one another in practice. We require to exercise foresight, that is, settle matters in advance of their happening. At the same time we have to preserve flexibility, so that in the event of their not happening as foreseen, confusion and tangle will not ensue. This is, of course, something like the old philosophical problem of trying to reconcile Freewill with Predestination, only in our own case we are compelled to find some working solution of the conundrum. It is not surprising that many practical managers, who thoroughly understand both the technical processes of operation and the successful handling of men, fail noticeably in maintaining an even and uninterrupted stream of work, rigorously exact as to date.

Analysis of the division of effort concerned in the control of work in progress shows that it runs in three streams—(1) Supply and Movement of Material, (2) Supply and Movement of Instructions, (3) Actual Operation. The co-ordination of these three streams is often somewhat complex.

The first and most obvious co-ordination is indicated by the fact that operation cannot take place until both material and instructions have met at the machine. The second co-ordination is that of time,—operations must be carried out in a predetermined sequence, so that successive stages of manufacture shall be reached by definite dates. This implies that material must flow or circulate on some basis of priority.

Expanding the analysis of the division of effort just made, it is observable that in the journey from raw material to finished stock, the fewest possible stages will be the following. The material must be:—

(1) Purchased.
(2) Delivered.
(3) Held in stores.
(4) Issued to shops.
(5) Circulated from machine to machine.
(6) Operated on at each machine.
(7) Inspected.
(8) Assembled or passed to stock.

Instructions must reach the different points at which material is handled in advance of or promptly at the moment when it is ready for the next movement.

These movements must not take place in haphazard order, but with a regular and predetermined priority, in many cases with strict adherence to a predetermined schedule of dates.

The co-ordination of these different classes of effort must be arranged in such a manner that changes in plan, cancellation or urging forward of orders, spoilt work, and the innumerable troubles of every-day factory experience are easily and instantly responded to by the persons concerned, without the "system" getting into tangles or requiring heroic struggles to get the paper part of it back into correspondence with the physical facts.

We must avoid an inflexible routine as we would the plague, while keeping the principle of foresight and pre-arrangement well to the front. It is therefore desirable to examine the question of instructions and so ascertain which things can be settled by the exercise of forethought without committing ourselves thereby to a rigid chain of consequences which will hang around our necks like a millstone if the unexpected happens, as it surely will sometime or other.

Fixed Elements

Certain things are necessarily specified in advance and are so fundamental that if changed it may be said that a new piece will result. These are:

(1) Design, or the shape and size of the piece.

(2) Nature of the material.

(3) Dimensions, limits and fits.

These are the usual instructions given on the shop drawing, and modern practice demands that each piece shall have its separate individual drawing. These items of instruction are so bound up with the production of one particular piece and no other that there is no option but to make them the subject of forethought. As far as the shop is concerned these instructions are unchangeable, since to depart from them would be to produce something else than that specified.

As has been discussed in the chapter on Design, certain special tools may be considered part and parcel of the individual design. We thus add:—

(4) Special jigs and tools for the job.

Up to this point there is no infringement of the principle of flexibility. If, however, we carry the principle of forethought any further we do begin to limit possible variations of working, thus:—

(5) Statement of the successive processes, indicating the machine, or at least the type of machine, on which the work is to be done.

(6) Date at which each stage of operation should be reached.

Further, if we have adopted any of the numerous systems of payment by results, we have to add:—

(7) Time allowance for each process, and for setting in each case.

In these last three instructions we have obviously begun to interfere with the autonomy of the shop, and to that extent have introduced a certain rigidity of routine. We have now to discuss the question—Is this interference good, or bad?

All discussions on the subject must assume one thing, namely, that the decision can be made in advance *by someone who is as fully qualified or more qualified than the foreman to make the decision.* All the systems employing elaborate planning, routing and despatching departments have this as their weakest point. If an initial error of judgment is made it is woven into the system. To rectify it means trouble all along the line. Calling the way selected by the planning man "the one best way" is of course very natural, but humanly speaking it is very likely to be untrue because only in very simple problems indeed is there "one best way".

The disadvantage may be looked at first. In the case of a really difficult piece of work the chances seem in favor of the man in the shop who is actually in physical contact with the job. Again the foreman bossing the work is more likely to have his heart in the business if he is doing it in his own way. Thirdly, flexibility is at a maximum,—nothing is upset by the job being done in this way or that.

Advantages of Habit

Now the other side of the question. In a manufacturing business — where the same piece is going to be made over and over again, month in and month out—a standard way of making possesses very great advantages. We establish habit. Habit breeds skill and speed, and promotes clock-like working. A change of method after it has once become habit should be ventured on *only* when the advantages to be gained are very obvious indeed.

The advantages of habit being admittedly great, it is important to set it going in the right groove, or as near the right groove as after careful consideration seems possible. This means that a specified way of processing should be made part and parcel of the design, and be as intimately connected with the piece as its physical shape.

This is, however, very far from being a matter of hasty decision by any one person, however fertile in inventing "best ways" he may be. It means co-operation between the designer, the draftsman, and someone with the highest degree of practical skill available. In many plants that someone is likely enough to be the foreman himself, or even a departmental foreman, a specialist in milling or grinding.

This brings us back to the point that the designing of work ought not to be divorced from machining considerations, but should proceed hand in hand with them. There seems no escape from this position. To do otherwise is almost inevitably to get away from the closest line of profit.

In general engineering plants, where things are made perhaps once only and not manufactured, specification of the machine processes in advance, instead of in physical presence of the work, is much more dangerous. It seems more debatable to employ two highly skilled men (for we should assume that the foreman is necessarily the most competent), one to specify what the other is to do. In the present discussion, however, we are treating of manufacturing plants as representing the prevailing form of industry.

If the decision is wisely and carefully made —and the "if" is the kernel of the problem— the practice of specifying in advance both the process and the machine presents great advantages. We have sacrificed a little flexibility but we have gained a standard way of working which, if not the only one, yet must be considered as good as any other, from the careful way in which it has been arrived at. From this follow several developments.

Specification in Advance

First, the problem of setting, and the tackle required in connection with the particular machine, can be investigated. This tackle becomes an integral part of the job, and takes its place on the "Book of the Plant", if new. Whether new or not, it is indicated on the drawing. By "tackle" is meant any holding device, which may vary all the way from a complex jig to a bolt-and-clamp.

Secondly, the time that should be taken to do the job can be studied in relation to the particular machine, and the particular tackle provided. This time should be separated into setting and machining time, and on the lines indicated in the second article, compared by area with other working time on that machine, and by ratio with other setting time. This will serve as a verification, or at least a means of checking the results arrived at.

Thirdly, this time of operation during which the job is occupying the machine being known, we can do what in some plants would be very important, namely, ascertain the "loading" of our machines, so as to know for considerable periods in advance what jobs would be reached by them, and so control promise of deliveries.

One other question remains, and it is a difficult one. We have gone so far as to specify a number of things in advance: dimensions, material, tools, processes, machines and jigs or tackle, setting time and machining time. How much farther should we carry the process of specification? Should we specify every motion of the man, or should we not?

We have discussed this question briefly in Chapter IX, under the head of "Habit". Generally speaking, motion study is valuable when it tends to the setting up of new and better habit. If a part has to be made a million times, it is obviously of great importance that the very shortest way of doing so, involving the least effort, should be employed. Having discovered this "best way", the next thing to do is to impart it to the operative so that he will discard his old way or habit of doing the work, and fall into the new and more efficient habit. This seems the touchstone by which we must test the employment of the somewhat expensive method of analysis called motion study. Is new habit to be formed? If so, then it is merely balancing the cost of the motion study against the gain expected from this new habit becoming standard. If the circumstances are such, as from the rarity of the work, that no new habit will be formed, then motion study seems superfluous.

As pointed out in Chapter XV, in many industries the place at which motion study should be applied is not the product but the machine. Where machines are limited in range, and it is possible by motion study to set up new and better habits of operation, then its value cannot be over-estimated. Every such application is a clear gain. But in industries such as machine shops, where machines are "general" in range, then it becomes a question of either raising the standard of the whole business of operating machines, by careful analysis of all their peculiarities, and then training men in new ways of operation, or on the other hand, confining oneself to carrying out this form of analysis on the components themselves, and this last way can be profitable only when it can be translated into new habit.

Thus far our arrangements have not led us into any very complex interaction of wheels and teeth. What we have considered advisable is really a case of "knowing all about the job" as we found in Chapter XV that it was desirable to know "all about the machine". We have simply embodied our ideas about the suitable method of doing the job alongside our ideas of the shape and dimensions of the job. We have lost flexibility to the extent that we have selected one type of machine, or in some cases one individual machine out of many, but if as an exceptional case it were found indispensable to do the job on another machine, nothing would be disjointed except possibly the time allowance.

The problem of co-ordination is of course simplified in proportion as we lay our plans in advance, and limit the possible variations that may take place at the various stages of the work as it progresses. But the disturbance arising from such variations if they do happen after all is materially increased. The game of chess, with its pieces moving in various but strictly limited ways is the most perfect example of co-ordination that exists. But in a game of chess, if we displace a piece the whole game is ruined. Many plants are burdened with systems arranged on the principles of chess.

Organization on the chess principle must be avoided at all hazards. Each stream of movements should be free and independent, and co-ordination based on the physical arrival and presence of the material at stage after stage. In view of some of the elaborate (and expensive) planning systems that are frequently talked of, this conclusion may seem to some people somewhat reactionary, but I believe that, whatever its theoretical poverty, it represents the only sound *practice.* It is not what should happen, but what does happen, that is the safe guide as to what is to happen next.

Co-ordinating Materials

Co-ordination of the streams of material is, as already mentioned, of two kinds, namely, as to place and as to time. In other words, we are constantly seeking answer to the two questions—"*Where is it now?*" and "*When will it be ready?*"

The answer to the first question is mainly a matter of good bookkeeping. Methods of keeping costs are almost as numerous as days of the year, but no system can be considered as satisfactory that, while serving its main purpose of recording the cost of each process on each part, does not also serve the purpose of indicating, graphically and exactly, how far each item of an order has progressed, and thus locate the position of every casting, forging or piece being worked on in the shops. With this information placed on an accurate and prompt basis, the problem of co-ordination is greatly simplified.

The answer to the second question, "When will it be ready?" is not so easily arrived at. The time taken by a component to get itself made is obviously not merely a sum total of the setting and operation times of its processes. In every shop there will be an average time taken for the "circulation" of pieces, depending on the number of processes they have to go through, quite apart from the machining time, corresponding to the average time of a train, which includes stops, delays, time at depots, *etc.,* in addition to actual running time.

The usual practice is to fix a delivery date for the completed job on the assumption that everyone concerned will keep it in mind. But where a proper cost system, arranged for locating parts, is in use it is probable that the best practical way to control the flow of work according to dates is by fixing an average time depending on the actual circumstances of the shop, for each successive stage of operation, and dating the job itself at the day of starting it, so that every one that meets it knows whether the piece he is actually working on is already delayed or not. *Then keep a watch on the exceptions,* on pieces which are notoriously behind time.

If, for instance, a piece has arrived at a stage that it should have reached in four days, and it does not get there till seven days have elapsed, that job calls aloud for help. It enlists the good-will of everyone to push it along. This association is better than the usual association with a future date of delivery for the whole job, because in the latter case human nature is very apt to leave it to the other fellow to make up the lost time. It is easier to recognize the fact that a piece *is* late, than that it *will be* late farther on in the chain of operations.

These two questions are present in every shop, however simple or complex its degree of organization. Successful answers to them must precede any attempt to realize a high degree of co-ordination. It is the imperfect answers to these questions that the ordinary shop is alone able to furnish that render complex systems attractive, if they appear to promise such answers.

We have now to consider co-ordination proper, that is, the setting in motion of the streams which shall afterwards meet together in due time and place, and so realize the programme. In this as in other things to start right is half the battle. Consequently the provision of material, including in that term the accessory tools which will be required in dimensioning the piece, will be the first consideration.

Certain elements of the circulation or "flow" of the material (and therefore the work) may be enumerated. These will be put into the shape of responsibilities:

(1) Some one must be responsible for seeing that the material is in stock or, alternatively, ordering it.

(2) Some one must be responsible for drawing the material out of stock and get-

ting it to the place where it is to be worked on.

(3) Some one must see that the operation takes place and is satisfactory, and that jobs are handled in order of urgency. Inspection is frequently a separate responsibility, but not always.

(4) Some one must see that the job is passed on to the next place of operation without delay. If the piece is finished it will go for final inspection to stock or to assembly room, as the case may be.

These four elements represent the minimum routine. In addition there should ordinarily be:

(5) Some one to attend and inquire into the "exceptions," namely, those jobs which are not coming forward in due time, or to which accidents have happened.

Desirable conditions are (a) as few pieces of paper as possible, and (b) as little interlocking of future effort as possible.

It is not the object of this article to indicate definite ways of doing any of these things, but to show the underlying principles and conditions that must be observed in *any* successful solution. It will be obvious, for instance, that that kind of system sometimes known as the ''way-bill'' in which the order accompanies the job throughout its progress, or the ''engineering'' method in which instructions are sent simultaneously to all concerned, equally fall within the conditions specified. Neither of these is a ''best way'', in the abstract. Similarly no specific arrangement for the co-ordination of responsibilities is a ''best way'' except for the special case it has been adapted to. It is much more important to understand exactly what are the elementary conditions than to attempt the determination and fixation of constructional details which would have no universal application.

Prompt provision of the material (element 1), is not the simple thing it looks. It implies the keeping of an adequate stock of material adequately catalogued, of course, but it also demands a higher efficiency in the purchasing department than is frequently realized in moderate-sized plants. An elaborate system of requisitions, orders-in-triplicate and so forth, in charge of a bright hustling junior do not make a purchasing department. There is no place where specialized experience can make itself felt more usefully.

The prime object of a purchasing-store-keeping organization is to provide material when required. Its second object should be to keep down the amount of capital locked up in material. The end to be attained as indicated by the principle of conservation of effort, is *not an accumulation but a flow of material.* The cheapest place to store material is in the supplying firm's warehouse, and a competent purchasing agent will set himself to discover and cultivate relations with those firms who can be fully depended upon for deliveries at short notice and faithful performance of promises, rather than lock up large capital unnecessarily.

No question of co-ordination or of interference with flexibility arises at this point. Whether the material is checked off from a "bill of material" or from the individual drawing as it is issued, its place of departure is the same, namely, the stores. All that is done at this stage is to insure that it is or will be there when wanted.

Movements of Work

The next element (2) is, however, a point of departure at which different systems diverge. How shall it be passed from stores to the first machining center? Shall it be, so to speak, "left till called for" or shall it be delivered automatically whether it is wanted at that precise moment or not? As element 4, referring to the subsequent movements of the job between machines, involves the same class of problem, some discussion may be devoted to both of them at this point. The whole question of "despatching," or nearly the whole of it, is in fact involved here.

It is sometimes supposed that "despatching" owes its origin to one or other of the schools of "scientific" management. This is by no means the case. As far back as 1898 the writer made use of bins or racks in which each machine's jobs were arranged in sequence, together with graphic methods of showing the progress of every process on every part of each job in a large machine shop. There was no great novelty in the idea even then. Much of the subsequent progress has been in the wrong direction, namely, in decreasing flexibility and imparting rigidity to methods of despatching beyond the needs of the case.

Material does not move of itself. Therefore it is obvious that instructions must be issued, by someone and to someone, before it will get transferred stage by stage in its journey. These instructions may be verbal or written; they may be based on the actual need of the moment, or be part of a prearranged plan. The method of solving the problem may be all the way from very simple to very complex, but again it is hard to discover that there is any ''best way''.

In some plants, where the product is constant, the stages of operation easily recognizable, and the destination of pieces always obvious, movement of work becomes habit or tradition, and the duties of the personnel towards it become automatic or sub-conscious. This is not only the limit of simplicity, it is also the limit of conservation of effort, and therefore of cheapness or economy. No effort is wasted; all that is applied is applied directly to moving material, and none to red tape. This happy condition cannot be realized in all plants, nor in any plant where the product is not uniform and invariable.

Generally speaking, however, the nearer we keep to making the material do its own signalling or ''despatching'', the nearer we shall keep to simplicity and, above all, flexibility. That is to say, the fact of completion of a stage or process should be in itself the signal for transfer of the material to the next machine or production center. This, combined with an adequate cost system which enables close watch to be kept on the *progress* of work, will usually control circulation in a satisfactory manner.

As most practical men are aware, the core of the trouble in many shops is not so much making a choice among several "waiting" jobs, as to get the knowledge of the physical arrival of the material to the right quarter—promptly. In many shops piles of work all over the floor make it very easy for a perhaps important job to be overlooked and delayed. Yet no very elaborate scheming in advance is necessary to prevent this. Methods of quick *identification* of the job are necessary, and in some plants this is attained by ensuring that every casting and forging bears identification marks so placed that they will not be machined off till the final process, or not at all.

Where this is done, and if it is accompanied by a cost-tracing system that tells the story of delayed parts and processes day by day, control of circulation will be sufficient to give satisfactory results on the one hand

and preserve the maximum of flexibility, with the minimum of red tape on the other.

It will be noticed that the method herein advocated, based on the necessity for co-ordinating effort and the desirability of conserving it, makes considerable use of the principle of exceptions. Having made a good start, by providing first the necessary instructions, as full as necessary, and the necessary material ready for use, and having assigned certain dates by which each stage of manufacture should be completed, the control of circulation of work rests first on adequate and prompt records of *significant* information coupled with a constant scrutiny to detect accidents, irregularities, and things not happening according to programme. When these are detected they are made the subject of personal investigation by someone detailed for that purpose.

The theory underlying this arrangement is based on the practical fact that though it is possible to plan very definitely in advance, it is impossible to foresee accidents and exceptions. When these happen they must be set right by personal effort and by no other means. Therefore it is better to recognize this from the start, confine the forward planning to those elements which are either not subject to change, or to those in which change will not be a serious matter, and then scrutinize what does happen carefully and completely. Where matters are not going right, swift personal attention from someone in close touch with the flow of the work gives the best chance of ultimate success. It will be understood that the satisfactory working of this method depends upon the promptness and accuracy with which the actual happenings in the shop are recorded, and their grouping and marshalling in a form indicating things demanding attention.

Law of Efficient Flow

In considering the question of the flow or stream of work, with a view to comparing the efficiency obtaining in any particular plant, it is well to keep in mind the conditions at which this flow achieves maximum efficiency. Maximum efficiency *as regards flow* is achieved when each machine in the plant is continuously engaged in producing one single component of the product, the output of the various machines being so proportioned that all the components turned out in the shop are assembled as fast as they are produced; also where the supply of raw material is so provided for that the quantity of raw material carried in stock is not more than absolutely necessary to prevent shortage which would stop the stream of production. Further, on the commercial side the flow of work is at its best when the manufactured and assembled product is sold and delivered as fast as it leaves the shop.

These conditions can rarely be realized in the kinds of business that approximate to the "engineering" type, but for any type of business they represent what would be the highest efficiency—because the quickest turning over of capital—could they be realized. The nearer any business can approach these ideal conditions the nearer it will be to absolute efficiency, regarded from the point of view of the flow of work. Properly regarded these conditions become a measuring rule by which to compare the actual conditions in a plant. Some of them will be seen at once to be impossible of attainment owing to the nature of the work, but the most skilful organizer will be he *who gets with the means at his disposal the nearest approximation to this continuous stream of production* that his conditions will allow.

Recapitulation

There are two elements in the control of work—desirability of exercising foresight, and necessity for preserving flexibility, which are antagonistic. Solutions must be a matter of compromise.

Certain elements of jobs are necessarily fixed and unchangeable, others are subject to exigencies as they arise. The latter should be brought under regular routine, provided the nature of the work permits, and only as far as it permits.

The object of motion study is to form new habit. Consequently it will pay to study thoroughly all product that is to be made over and over again with a view to determining the best routine for it, where it would not pay to apply the same methods to occasional work for which there is no regular demand. It will pay best where it can be applied to the machine rather than to the individual items of product.

Most of the opportunities for exercising foresight could be most usefully seized in connection with the original design or drafting of the component. Designing should not be divorced from machining considerations.

Co-ordination of work in shops should

be based not on what should happen but on what does happen. The latter is the only safe guide to determine what should happen next.

Successful co-ordination of work should always be able to answer the questions—"Where is it now?" and "When will it be ready?"

The elements of the flow or stream of work can be stated in the form of five kinds of responsibility. Each of these must be efficiently discharged.

The conditions of maximum efficiency in regard to flow or stream of work can rarely be attained in engineering plants, but any plant will be proportionately efficient in flow as it gets nearer to these conditions.

3. Second Law of Effort (continued)—Remuneration of Effort. Special reward in regard to the different departments of Control has hardly, as yet, received any consideration. In the higher posts comprised in this function, it seems unlikely that anything but a salary basis will be found desirable. But the routine work of store-keepers, order clerks, tracers, *etc.,* is another matter. It does not seem unlikely that some form of special remuneration or bonus, based on absence

of errors, delays, misunderstandings, and forgetfulness will eventually be brought into use. The Control function being divisible into groups, such as those men concerned with store-keeping, with handling and conveying material and product, with clerical work on orders, with tracing and "despatching", *etc.,* would seem to offer a promising field for the application of some form of group incentive, based on smooth working and absence of hitches. In this function, also, premiums may be offered for suggestions leading to improvement in the methods, and the removal of observed hindrances to the free circulation of material or instructions.

THIRD LAW OF EFFORT. Vocational fitness is one of the principles of the Third Law of Effort that may be regarded as of special importance in Control. A number of different types of mentality will be employed, and these will of course be more suitable for certain work than for other work. Some study of the qualifications for each post, in the light of the special mental qualities desirable, such as memory, quick observation, discrimination, *etc.,* if carefully carried out by competent psychologists, would lead to interesting and valuable results. All this, however, is a matter for future development. The other principles of the third law should also be applied to the personnel of Control, but as explained before, this law applies to men as individuals, and not in their functional capacity.

TABLE XVIII. PRINCIPAL APPLICATIONS OF ANALYSIS IN REGARD TO CONTROL.

1. Analysis of the material situation, to determine its requisition, purchase-ordering, receiving, storing, handling or conveying, and issue to shops.
2. Analysis of the product situation, to determine its receipts by shops, passage from production center to production center, and subsequent delivery into stores or warehouse.
3. Settlement of spheres of duty, based on (1) and (2).
4. Analysis of the customers' order situation, to determine how they shall be received, accepted, delivery promises made, dissected departmentally, and passed to persons concerned.
5. Settlement of spheres of duty based on (4).
6. Analysis of the employment question, to decide on appointments, qualifications, and rates of wages or salaries.
7. Determination of the method to be adopted as to rate fixing for piece-work, or bonus jobs—whether based on time study, standard price-lists, or fixed by a foreman or rate-setter.

TABLE XVIII. PRINCIPAL APPLICATIONS OF ANALYSIS IN REGARD TO CONTROL (*Continued*).

8. Settlement of spheres of duty based on (6) and (7).
9. Analysis of the stages at which, in complex industries, instructions have to meet material, with a view to establishing a control office or planning department to co-ordinate such movements.
10. Settlement of spheres of duty based on (9).

APPENDICES

I. The Labor Question.
II. The Expense Burden in Relation to Piece Work and Premium.
III. The Expense Burden in Relation to Bonus.
IV. The Planning Department.
V. Some Axioms of Administration.

Appendix I

THE LABOR QUESTION

THE question of incentive as regards operation is so important a subject, including as it does what is commonly termed the Labor Question, that it merits discussion at some length.

The industrial problem is, in the main, a dispute as to the division of the proceeds of industry. There are two extreme ways in which these proceeds can be divided. First, the method largely in vogue at the beginning of the factory era, namely, that labor's share is just as much as will barely keep it alive and no more, and that all the rest belongs to capital. Second, the exact opposite of this, namely, that capital shall only receive just sufficient return to remunerate it for its risk, and that all the rest shall belong to labor, including of course both handwork and brainwork in the term "labor".

The modern tendency is away from the former and towards the latter system of division. In one of the largest and most closely organized trades of the world—the British cotton industry—this kind of division was carefully discussed and very nearly adopted a few years ago. The scheme failed, not from any disagreement in principle between the employers' federation and the men's union, but because of squabbles as to how the figures were to be arrived at.

Two Aspects of the Question

It is important to realize the existence of two entirely diverse aspects of the labor question. The difference between them has been generally overlooked by economists. First, there is the question how far labor *as a body* shall divide with capital the proceeds of industry. On this question the individual members of the labor body are usually in accord. It is to the interest of each and every one that this share — the "wages fund"— should be as large as possible.

Then there is the further question how, out of the division allotted to or claimed by the whole body of labor as its due share, the *individual worker* shall benefit — whether he shall be compelled to limit his production to suit the capacity of the average or even of the least skilful men in his trade, or whether he shall be at liberty to exercise his skill to the utmost, deliver more work than and consequently reap a larger share of the wages fund than the average man, and a considerably larger share than the least skilful. The same unanimity between individual members of the labor body does not exist on this question as on the other. The problem of the worker's relations with his fellow-workers is closely bound up with this second question. The interests of the more skilful and the less skilful are obviously not identical, and in a few cases are really opposed. Where only a limited amount of work exists, as in some subsidiary trades, this opposition becomes very marked, and various abusive terms are applied to those workers who deliver more than an average output, and consequently get a larger share of the wages fund than the average man.

The reward of *the whole body of labor* is controlled by the different scales of pay which use or custom has set up for different occupations. These different scales have been worked out by the slow process of trial and error, and particularly by the way in which the supply of any given kind of labor offers itself. In the same trade they vary in different localities, having in general some relation to the cost of living. It will be perfectly evident that there is no necessary relation between the wages thus current and usual, and the earnings of the capital that employs such labor.

It will also be evident that this total share of the whole body of labor in the proceeds of industry is quite independent of any method of calculating earnings. All bonus methods *have to take as their starting point the customary wages in the trade,* and it is precisely these customary wages that control the ultimate division of the proceeds of industry.* The British cotton trade, for example, is very largely based on piece work and on a premium system referred to below but this does not prevent the workers from claiming 5 or 10 per cent rise over the whole price-list when trade is good, and the employers claiming a similar reduction when trade is dull. The *relative* distribution of

* A curious instance of the influence of the customary wages of a particular locality on piece prices is given by Dr. Victor S. Clark (Labor Bulletin 80. Washington, 1909). Speaking on the earnings of girls engaged in the Birmingham, England, industries, he says: ''In all cases piece prices are fixed by the customary wages for women in the district, and the rates reduced or increased till the wage earned by piece work approximates *to what the girls expect to get''*.

proceeds *within* the trade remains as before, and is controlled in its distribution by the piece prices, but the total share of labor as a body rises and falls.

The difference between these two aspects of the division of proceeds will be more clearly seen if we regard the case of a co-operative plant, in which the workers are the sole stockholders. In this case the body of labor gets *all* the proceeds, but the division within the body of labor is not necessarily equal. It is still determined by customary rates for each different occupation, and piece work is not even precluded, whereby men earning the same customary rates do more or less of the total work, and therefore receive more or less of the total divisible proceeds.

This division is also illustrated by the curious scheme proposed by the French economist Yves Guyot, who suggests that manufacturers should contract directly with the unions for a certain quantity of production at a fixed price. In this case a certain share of the proceeds of production is allotted to the whole body of labor, and the manufacturer has no concern with the individual's reward. This is in fact an approximation towards the system of those mediæval guilds under whose rules no merchant could purchase labor of an individual worker but only labor embodied in product, under the rules of production maintained by these guilds.

Present Tendencies

The only thing, it would appear, that can set this question at rest, is the determination of what is a fair share for capital to take. That is a far simpler problem than the other. It is the condition to which industry seems to be progressing. And certainly the greatest hope for industrial peace lies in the frank acceptance by employers of the principle that in any trade (that is, the trade at large, not necessarily the individual business), the reward of labor shall bear some proportion to the total proceeds realized. Various attempts have been made to give this very modern idea practical expression. Sliding scales of wages, profit-sharing schemes, and so forth, have been tried, but with only mediocre success save in a few instances. Nevertheless the bringing in of labor as a partner in industry will probably be realized before many decades have passed.

It will have been seen from the foregoing that while the division of the proceeds of industry between capital and labor is controlled only by customary rates of wages in any occupation, the reward of the individual worker on the other hand, when on piece work, depends on whether or not he delivers more work in a given time than it is the usual practice of labor to deliver in such time. It is the general contention of the employer that he has the right to stimulate the individual and spur him to increase his work above the average by special rewards for so doing, and it is the general contention of the unions on the other hand that he possesses no natural right to do so, and that as a matter of policy the unions will not permit him to do so to any greater extent than they can help. The setting of a definite task has been fought by the unions under many forms and in many places time after time, sometimes secretly and sometimes openly, on the ground that speeding up is in several ways wholly inimical in the long run to the interests of the individual so speeded, and of the body of labor at large. There are, however, notable exceptions to this attitude, which will be referred to later, as affording valuable practical hints.

Before proceeding to discuss task work, however, it may be pointed out that modern methods of management contain two distinct elements, between which little distinction has been drawn hitherto, although this distinction is of great practical importance.

These two elements are:—

(1) Conserving effort by eliminating wastes and false motions of various kinds, which it is claimed exist in most industries.

(2) Carefully measuring the amount of effort legitimately entering into the job and remunerating it by some system of task work.

In industries which happen to be conducted on a high plane of efficiency already, it is evident that no fund for the increase of wages or of profits can be extracted from the first of the above elements. In that case the only savings possible arise from element (2), *viz.*, the stimulation of the worker to deliver more than the usual amount of work that it is his practice to deliver under the customary day wages of his trade. In other words, there is no magic principle in any new method of management that specially tends to raise wages to a new and higher level, except in so far as the elimination of large wastes in a plant may provide a new fund for this purpose.

It is important to notice also that the operation of element (1) is not a continuous process. It is based on the assumption that owing to the haphazard growth of industry, present-day manufacturing practice is full of avoidable wastes. If, today, by the elimination of considerable wastes in any industry a greater margin of profit were to be created, it is certainly open to all concerned to divide this "melon" equitably, some of it going to labor in the form of a higher rate of wages, some to capital in the form of higher dividends, and some to the consumer in the form of a lower price, *but when this has once been done,* the future relations of capital and labor remain precisely as before. The question of their relative share in the future remains as in the past, because no new principle tending to solve it has been introduced. The accurate measurement of effort, by itself, does not of course tend to raise wages. It may even have a contrary effect.

Pros and Cons of Set Tasks

The prejudice of unionism against set tasks at a given price, *i. e.,* any form of remuneration by results, whether based upon accurate measurement or not—is founded on five ideas, *viz.*:—

(1) That it takes away the other man's share of work.

(2) That it over-stimulates the worker, to his ultimate harm.

(3) That it is used as a means of "weeding-out", meaning the gradual elimination of the average and the less capable men in the trade.

(4) That the price of tasks always tends to fall.

(5) That it leads to favoritism.

On the other hand, the employer's side of the question is founded on five main considerations, *viz.*:—

(1) That time payment is payment for a vague and uncertain thing.

(2) That task payment arouses the worker's interest in devising short cuts and in cutting out unnecessary wastes.

(3) That task payment creates "self-discipline".

(4) That task payment enables the selection of the man most fitted for each task.

(5) That task payment lowers cost per piece while increasing the individual worker's earnings and the output of the plant.

Both these statements are very moderate and temperate abstracts of arguments used by either side. It is hardly necessary to say that extremists go farther, varying all the way from allegations on the part of labor that any system of set tasks is a deep laid plot for the enslavement of the worker, to allegations by "efficiency experts" that they would bring about the millennium if it were not for the crabbed opposition of the men.

That both sides "agree to differ" on the merits of the question is not wonderful when we observe that, with one exception (and even this exception bears different interpretations) none of these assertions on the one side cover the same ground as the assertions on the other. The exception is that the process called "weeding-out" by the unions is called "selecting the right man for the job" by some employers. Otherwise any of the ten assertions may be true, and perhaps all are more or less true today.

Space does not permit the full discussion of each one of these ideas, or an examination of its bearing on the question of efficient production. We must address our efforts mainly to an attempt to discover some practical principle of working that will satisfy as many as possible of the objections of labor, while preserving as many as possible of the advantages claimed by the employer. The first objection, *viz.*, taking away the other man's share of work, is not of universal application. Whilst in some special industries it is unquestionably true, it does not apply with any force to others, *e. g.*, the engineering and metal-working industries. In these industries the law that decreasing price of an article gives rise to increasing use and demand is generally true. And as a matter of fact, this idea of a fixed amount of work, though still commonly met with, is less strongly held by engineering and metal workers than by many other trades. We shall not therefore go deeper into this objection on the present occasion.

Eliminating this somewhat old-fashioned objection from our discussion, we are left face to face with a series of contentions and objections that are largely dependent on the presence or absence of reasonableness and good faith in the relations between employer and employee.

The Cutting of Rates

It will be noticed that the remaining objections raised by labor are rather against the abuses which may arise (and it must be conceded frequently do arise) from the adoption of piece work, premium or bonus, than against a moderate and fair use of the principle itself. It will be readily admitted by both sides that the well marked tendency of piece rates to fall, owing to price cutting, is the really strong ground on which the objections of labor are based. This practice, in fact, puts labor in much the same position as regards definiteness of remuneration as the employer is in when he pays for labor on the day-work plan. Under these methods, labor delivers a set amount of work, but is never sure that its reward will continue to be proportionate to the effort. Under day work the employer is never sure that the efforts of labor will be in proportion to the customary wages paid. Neither of these positions is satisfactory.

It is claimed that certain premium and bonus systems remove all temptation to the employer to cut rates. This contention is fallacious, unless such close determination of time-allowance has been made that it becomes *impossible* for men to increase output greatly and so earn excessive wages compared with their customary wages. Whether this can be actually done is discussed later in this article, but if it *is* done such systems become mere devices for forcing the pace, or in the words of a prominent advocate of one of these systems—"*One of the objects of our plan of bonus is to fill the shop with selected thoroughbreds"!* Such an attitude will certainly be fought by labor unions in the future, as it has uniformly been in the past. Instead of contributing to industrial peace, it will sooner or later, when its operation is clearly perceived by labor, tend to the bitterest opposition, and a re-opening of the whole question in an acute form.

The fallacy that there is anything particularly new in the various systems of premium and bonus, either with or without accurate time-study, cannot be too clearly understood. Though re-discovered today, as regards the mechanical industries, most of these devices have been experimented with since the beginning of factory industry. As far back as 1835, a premium system, combined with time study, is described by Dr. Ure in these words—"The productive power of his spinning machine is accurately measured, and the rate of pay for work done increases *with* though not *as* the increase of its productive power''. In other words the saving is divided between employer and workman precisely as in a modern premium system. Again, in the British textile industry a premium system has been in use for over 35 years, *viz.,* since 1876. In that year what is called a ''speed list'' was adopted. ''Payment is by result, calculated from a certain standard of speed, *viz.,* 3 draws in 50 seconds; for each second saved so much is added to the earnings, *being one-half the advantage* of the difference arising from the increased speed.''* That is to say, a 50 per cent premium rate.

The ''day-and-a-dollar'' system that led to so much trouble in the iron-foundry industry was another variety of ''stimulus,'' differing from other systems of remuneration rather by its crudeness than in principle—in short, there are many varieties of calculating wages, and adjusting them to effort, all of which have failed at some time or other to prevent industrial trouble. That is because whatever basis is fixed, and however

* Shadwell's ''Industrial Efficiency.'' P. 393.

"scientifically" it is determined, just as soon as men reach excessive earnings, owing to the man's share of remuneration bearing a *constantly increasing ratio* to his day-wages (and this is the case in all existing systems without exception) the employer will be tempted to cut rates, and under the stress of severe economic pressure, bad trade or hard times, or keen competition, certainly *will* cut them, all the fine phrases of the inventors of these schemes notwithstanding. None of them differ so much from ordinary straight piece work that any new principle, sufficient to overcome the employers' desire for self-protection, can or does come into operation, when they are employed. A study of their curves, plotted geometrically, will convince anyone who doubts the truth of this statement. (See Appendix II and III.)

Realizing Industrial Peace

Industrial peace, however, can be realized, and as a matter of practice has been realized over long periods of time in some trades, by the adoption of certain principles of reasonableness and mutual fair dealing, about which there does not appear to be anything so peculiar to the special conditions obtaining in those industries that they could not be extended somewhat widely. Though dependent on some form of task work, inasmuch as some kind of datum line or measure of effort is obviously necessary before any bargain can be made about it, the particular system of remuneration does not greatly affect the result, if at all. Before discussing specific instances, the general nature of the problem must be considered.

The purchase of labor at a uniform price by all employers in an industry is as reasonable a proposition as that there shall be no discrimination in the purchase price of transportation, provided *that some measure can be found for the corresponding output implied when we speak of purchasing labor.* In practice, however, both in transportation and in the case of labor, this uniformity is a matter of locality, and is not nation-wide.

While it is obviously to the interests of labor that this should be so, many people fail to see that it is equally to the interests of the employer, particularly the better class of employer. Yet that it is, very brief consideration will show.

The prosperity of an industry depends on the adjustment of its productive powers to the average demand for its product. An industry may, and sometimes does, consist of one plant, but if it contain more than one, then there will usually arise a struggle between rival plants, one trying to extend at the expense of the other, or at any rate to expand at a greater rate than the other. Which plant will grow will depend on many factors, commercial skill being a prominent one, cost of production another. Frequently advantages in these directions average up. One plant will produce cheaper, but the other will sell more cleverly and aggressively. But where commercial skill is about the same, the struggle will take place on the arena of production. This struggle should be a struggle of brains and enterprise, but too frequently the victory is sought by cutting down the due and usual price of labor to the utmost that labor will stand.

This is a process wholly destructive, and there is hardly one single argument, either economic or moral, that can be used in its favor. Suppose the original employer to be a man who has gathered a contented body of employees round him, and created good conditions for their daily work; still there will come a day when, if his competitors are successful in cutting the price of labor, he will have to follow suit or go out of business. Meantime, by the substitution of poorly paid and discontented labor for properly paid and intelligent labor, the industry will suffer, and its product will almost certainly become degraded from its former standards of excellence. The public will be worse served by the products of the industry, and it is difficult to see who has benefited at all. For though the originator of the price-cutting may reap a temporary advantage, still he cannot keep it any longer than it takes the other employers to follow suit.

This is no fancy picture. It has happened over and over again, and is happening today. Its ultimate tendency always is to drive out the best class of employers from a trade, and the best class of labor, and to replace the former by sweaters, and the latter by a proletariat amongst whom the wildest doctrines of social upheaval find their natural breeding ground. This is, of course, most likely to happen in unorganized industries, and those not requiring much skill either in administration or labor.

The employer who undertakes to force down the price of labor, or allows his subordinates to do so, is then first of all the worst kind of enemy *to his brother employers,* as well as a bad citizen. It is to be feared that this point is but imperfectly appreciated by those who have suffered from the aggressiveness of unions, but a little thought will show that there is no escape from the truth of the proposition. A further and more impersonal effect is that the purchasing power of one section of the people has been restricted, and this restriction is felt, however microscopically, throughout all industry.

Prime Elements of Agreement

The fact is that there are but two elements to the question of the individual worker's remuneration, one of those being an absolute square deal between both sides, and the second being *adequate data to enable both parties to perceive what a square deal implies.* The first of those requirements is obviously a matter not of any kind of system of management or any practical device, but of personality alone; the second is mainly a matter of knowledge of facts—that is, of a method of determining prices and of accounting that commands the confidence of both sides.

There are two ways in which the supreme influence of personality is brought into play. One is the association of an exceptionally fair-minded employer with exceptionally loyal men; but this, though the more obvious, is really the less practical way of securing the good effects of personality, because it is largely a matter of accident and cannot be deliberately planned for and brought about.

The second and most efficient way is to appeal to the law of average. By associating a considerable number of employers with a considerable number of men, the idiosyncrasies of individuals, the blusterers and the malcontents, tend to become swallowed up and effaced, and a platform of mutual confidence on broad lines is more easily erected. Large and powerful federations of employers and large and powerful unions acquire a mutual respect for each other's powers of offense and defense that leads to really earnest efforts to preserve industrial peace. The larger the basis the more likely that reason will guide the councils of either side. It has been remarked by Mr. Carroll D. Wright,* than whom no one has a better claim to be heard on the subject, that it is the smaller

* See Report on Restriction of Output, 1904.

and weaker unions who are the most reasonable.

The great engine of industrial peace is unquestionably that of the standard price list, varying only to meet local scales of wages. This is the most satisfactory protection to the employer from the rival who, knowing his piece prices, starts in opposition to him by commencing with lower prices, and it is likewise an equal protection to the man against rate cutting. While it may not be possible to realize it in all industries, there are many examples of its practical value in securing long periods of industrial peace and what is equally important, a calm discussion of all points of difference and dispute. The British cotton industry is one of the instances where this system has been very successful in operation. The stove trade in the United States is another. Under the treaty between the Iron-Molders' Union and the Stove-Trade Defense Association, made twenty-three years ago, and modified in detail from time to time, there has never been a strike on the question of price—a truly remarkable record. These instances demonstrate the fact that labor's general attitude of resistance to task work can be overcome, not by any special system, but by adherence to broad principles of mutual good faith.

Trade-Wide Price Lists.

The careful determination of trade-wide price lists is, therefore, the first step toward a practical *modus vivendi* of capital and labor, in any industry, and several important points have to be observed.

First, the determination of price lists is a matter entirely independent of the elimination of wastes. These should be dealt with on their merits, if and where they exist.

Second, the influence of any special system out of the many existing systems of piece prices is nothing like as important as commonly supposed.

Regarded as a method of remunerating effort, straight piece work is more favorable to the worker than any of the later devices. Piece work is, in fact, simply premium at 100 per cent, whereas the ordinary premium rates are only 33 per cent or 50 per cent. This is the sole difference between the systems. It is obviously better to receive 100 per cent of what one saves, than only 50 per cent.

Ethically it is also a more attractive proposition if we regard the savings as due solely to increased effort, whether mental or physical, on the part of the worker. But if we regard the saving as due in part to auxiliary arrangements on the part of the employer *which he would otherwise not have had to make,* then somewhat different arrangements seem desirable. All existing systems of bonus and premiums are attempts to meet the desire for such arrangements.

Actually, however, both piece work and premium on a 50 per cent basis, the latter coupled with time study — have been in steady use in the British cotton industry for nearly forty years, as shown above. It is evident therefore that the particular system is not specially important, which, as they are variants one of the other, is not surprising.

Third, wherever possible, the assessment of piece prices should be associated with the maximum efficient use of a particular type of machine. This may vary all the way from elaborate analysis of every element of the machine's operation to simple speed and feed cards for each kind of material used. In some cases it need not be connected with individual product at all.

Fourth, the principle of a stint or standard of attainment fixed at some *fair* percentage above ordinary day-work output is very useful, and, if properly applied, far from an oppressive feature. Mr. Gantt has made successful use of this idea, though it has of course nothing to do with the special system of task payment that he employs. It can equally well be applied to any system of task work from straight piece work upwards. Its chief merit is that it provides a scale for the worker to measure his effort by, and to reach and keep in the top class. If the standard is reasonable this is not so much a stimulation as an encouragement, and an appeal to the sporting instinct that, when it can be enlisted, is one of the most powerful factors in successful effort.

Fifth, the question of cutting of rates must be courageously met. There are two ways in which this can be approached. First, by an ironclad agreement formally entered into that rates shall never be cut. This is successfully applied even by individual firms, but as has already been shown, it loses most of its value *unless,* by an industry-wide agreement with the workers, *the employer is protected against their being cut by competi-*

tors in the same business. The second way is by the adoption of a rate automatically falling as production is increased. The Rowan premium is of this class, but it has the drawback that it is not very easily calculated, and it depresses the rates much too quickly. But even such an automatic rate, though it assists the problem of the individual plant, does not obviate the necessity of an industry-wide agreement.

The main difficulty with regard to rate cutting lies within the following limits:

Influence of Repetition

In any system of task work, *long repeated,** it is evident that increasing skill will render the original determination out of date—unless it is assumed that time-study is capable of foreseeing and allowing for such increase of skill. Though this is claimed, it is obviously impossible in many cases. Even if the claim is allowed, it involves a dilemma. Either

* How far unexpected results may arise from long-continued repetition of work is instanced in the following case: "A certain linotype operator attained the extraordinary speed of 10,000 ems per hour, but so delicate was the adjustment of the muscles in this work, that if the man was called off for 15 minutes to do another kind of work, it so disturbed their equilibrium that it took him an hour to speed up to his former gait".

(1) The time limit is fixed on a basis of future skill, in which case it will yield poor results till that skill is acquired, or

(2) It is not fixed on a basis of future skill, in which case men's earnings will ultimately become disproportionately large.

The elements entering into the question of piece rates are, in fact, not yet fully worked out in their practical bearings by any of the existing systems. There are two halves to the problem, one concerning the different degrees of skill existing in any given body of men, and the other concerning the possible increase in skill arising out of long-continued repetition of the same operation. It has not yet been shown that these two halves have any relation to one another. In other words, it is not proven that the best workman on short jobs is necessarily the best workman on long-continued jobs. Experience points the other way.

Any working force is made up of

(1) Men below the average.
(2) Average skilled workers.
(3) Men above the average.

The first problem of remuneration of effort is to fix a fair price for the work of the average man; second, so to arrange matters that the man below the average is encouraged to acquire increased skill; third, to permit the highly skilled man to reap the full reward of his superior skill.

Even if this is satisfactorily done, there remains the further problem of *increasing* skill due to long-continued practice on the same work. It is this element, rather than the work of men above the average, that leads to cutting of rates.

While most of the numerous systems of payment, from straight piece work up to the latest development of bonus, meet the first half of the problem with about equal efficiency, if and when prices are based on accurate determination of the proper time allowance, they all fail to meet the disturbance caused by the slow development of skill arising out of long-continued practice.

It is unlikely that the last word has been said on the subject of wage formulas. Undoubtedly new ones will be developed to combine certain of the good features of the present systems without their disadvantages. One which would combine the definite character of straight piece work, with the "stint" or standard of attainment (which provides a goal for the worker to aim at), and at the same time would safeguard the question of increasing skill due to long-continued practice, and also the question of errors in rate fixing, is not perhaps impossible of development.

A study of the more prominent varieties of operation - incentive - piecework, premium, bonus, *etc.*—will be found in the two following chapters.

Appendix II

THE EXPENSE BURDEN IN RELATION TO PIECE WORK AND PREMIUM

THE fundamental difference between premium and piece work has never, to my knowledge, been adequately discussed. As a matter of practice, premium is supposed not only to be superior in results but also different in principle. We shall test thoroughly the soundness of that view.

The exact bearing of both premium and piece work on "total" or "works" cost reduction has hitherto received but little attention, while much has been written on their bearing on wages reduction. Yet of the two, reduction of "works" cost, that is, wages and burden (disregarding material as being outside the question) is the more important, both theoretically and practically.

The obscurity in which this question remains is largely due to the habit of regarding costs as merely the aggregate of wages and material, and of looking on "indirect expense", or "expense burden", as a rather theoretical thing that may be, and sometimes is, tacked on to costs, at the fancy of the accountant or some other system-loving person. When, however, we recognize that indirect expenses are passing minute by minute into the real cost of an article under process of manufacture, we not only widen our point of view in a very useful way, but are able to grasp more clearly the economic status of piece work and premium.

The object of any system of payment beyond simple day work is to stimulate production by making the workman directly interested in lowering "time taken". With piece work we appear to contract with him, with premium we appear to take him into partnership. Neither of these popularly accepted ideas is strictly true. Neither of them takes into account what practically is always the chief, and in some cases the *only,* benefit to the employer, viz., a reduced works cost due to savings on burden.

The present inquiry was undertaken with a view to analyze the differences and compare the results of premium and piecework in the light of total cost reduction. Most people have assumed that the tendency to cut rates which is so marked a feature of piece work, which is so greatly diminished by the Halsey plan and totally absent in the Rowan plan, is due to some very marked difference in principle between the first two, and a mere difference of detail between the last two. The result would appear to point the other way. Considering piece work and ordinary premium only, for the moment, there is no difference in principle between them at all.

Piece work is exactly the same thing as premium work, only, instead of the premium being 33 1/3 per cent or 50 per cent, it is 100 per cent. In all other respects they are fundamentally the same.

If we commence by disregarding expense burden altogether, or assume it to equal zero, it will be seen that a very important practical difference results from offering what is called premium instead of what is termed piece work. In the former case, only a half or a third of the total saving goes to the worker. In the latter, 100 per cent, or in other words, *all* the saving goes to the worker. It follows from this, that except in the light of expense burden, the employer's benefit from piece work is limited to advantages of no great economic importance

—(1), the time limit or "price" set for piece work is usually slightly lower than previous day work records; (2), a fixed instead of a variable cost is obtained for the piece; (3), the resulting concentration of the worker's attention generally produces, after a time, a more uniform and accurately wrought product; (4), a quicker output results, which is sometimes of advantage, but not necessarily always of advantage. The worker's benefit, on the other hand, is that he makes considerably higher wages.

The practical instinct of employers has, however, always realized two controlling elements: first, that expense burden has a vital connection with the question, and that an actual reduction in time taken means a reduced total or works costs, though it does not mean a reduction in wages cost; secondly, that after a certain point is reached, excessive earnings on the part of the man are out of proportion to the benefit from reduction in burden realized by the employer. How these two elements are really interconnected will be shown later, but that the desire to cut rates is not merely jealousy of the worker's high wages, may be gathered by supposing a case in which the work was given out to a homeworker or a small outside firm. In such a case, very few employers, having once made their contract, would trouble themselves at all as to whether the outworker was making "a good thing" out of the contract—even though they were fully aware of it. But when by use of the employer's own organization, machinery, and facilities the worker's wages become excessive, he, the employer, is inclined to call a halt. This will always be so, by whatever term the worker's reward is designated, as long as the premium is a very high one, as it is in piece work.

As will be shown presently, the trouble with piece work is that, with the expense burdens usually existing in machine shops, the man's share relative to the fall in works cost is always disproportionately high, and that under piece work, cost can never be halved unless the burden is well over 100 per cent (practically 160 per cent or higher). Yet the doubling of the workman's wages takes place long before this stage is approached.

In all systems of premium payment, whether the rate be 33 1/3 per cent or up to 100 per cent, a reduction of the time allowance brings benefit to the employer in inverse proportion to the amount of the premium. He gains by a share in the saving of wages cost (except in the single case where premium is 100 per cent, as in piece work) and he also gains by saving the indirect charges or burden on the unexpended time. Obviously, therefore, premium is not equally remunerative to the employer in all cases. The higher the burden, the sharper is the fall of the works-cost line relative to wages, as cost is reduced. At very low burdens—where the percentage of burden to wages is lower than the percentage of premium paid to the man—the fall of works cost becomes proportionately less sharp as cost is reduced. In piece work, therefore, where the percentage of premium is as high as 100 per cent, it may frequently happen that great inefficiency results though the worker may be making double wages. These points will be made clear by the diagrams which follow later. A few numerical examples will first be given; a 100 per cent burden is assumed in all three cases. Unit prices for unit time are also assumed (one dollar or one shilling for one hour)—the figures can therefore be read in terms of price or time as necessary.

A further analysis of the employer's saving tabulated on this page shows the relative influence of premium and burden in the result.

An examination of these three sets of figures will show that the employer's saving is made up of two elements—a saving of burden, which is of course strictly proportional to the incidence of burden only *and has no relation to the rate of premium,* and a share of the saving of time as expressed in wages,

MAN'S EARNINGS AND EMPLOYER'S SAVINGS AT DIFFERENT PREMIUM RATES
(Burden 100 per cent.)

	Premium 33⅓ per cent.	Premium 50 per cent.	Premium 100 per cent. (Piece Work).
I. TIME NOT REDUCED—			
Wages for full time...	100	100	100
Burden for full time...	100	100	100
Works Cost........	200	200	200
II. TIME REDUCED BY HALF—			
Wages for half time...	50	50	50
Premium Earned.....	17	25	50
Burden on half time..	50	50	50
Saving to Employer...	83	75	50
Original Allowance..	200	200	200
III. ANALYSIS OF SAVING—			
Saving in Wages (⅔ of 50) =	33	(½ of 50) = 25	(None)—
Saving in Burden (100 per cent on 50)......	50	50	50
	83	75	50
IV. RELATIVE SHARE—			
Man's Share of Saving:			
Wages...........	50	50	50
Premium..........	17	25	50
	67	75	100
Employer's Share of Saving............	83	75	50
V. REDUCTION IN WORKS COST—			
Percentage of Reduction...............	41½	37½	25

which share is wholly determined by the rate of premium. Where premium is 100 per cent, as in piece work, this share equals 0, and that is all the difference there is between piece work and any other premium rate.

It will further be observed that, in the case taken, where burden is 100 per cent of wages, the relative positions of man and employer, when time is reduced by half, are very significant. See III, page 433.

The disproportionate share of advantage obtained by the man under piece work is seen at once—when time is halved the man is getting twice the benefit that the employer gets, and though the man is drawing double pay the total or works cost has only been reduced by 25 per cent (50 on 200). The other two percentages show a different distribution of the saving as between employer and man, and therefore a different degree of lowering of works cost as shown in V, page 433.

The important bearing of expense burden on cost reduction under premium plans having been outlined, and, incidentally, the identity of piece work with premium in principle having been shown, their further relations may be examined in detail by means of the diagrams on pages 438 and 439, which represent four varieties of premium payment in their relation of burdens varying from 25 per cent to 150 per cent.

Explanation of the Diagrams

For purposes of comparison an allowance of 100 hours is assumed for the two premium systems, while for the piece-work system an equivalent price of 100 price-units is fixed—such price-units being 1 per hour. In other words, the ordinary wage rate is assumed throughout to be one shilling or one penny, one dollar or one cent, per hour—the monetary value being a matter of no consequence, as long as we remember that it is *one* per hour. The vertical column of figures represents rise in cost from 0 to 250 of such price-units (dollars, shillings, *etc.*). The horizontal figures represent "time taken" from 0 to 100 hours.

The thick line running diagonally from 100 down to 0 represents wages cost on the job. Thus 100 hours cost 100 shilling or dollars, 30 hours cost 30 shillings or dollars, and so forth.

The dotted line represents the *total receivable* by the man, made up of (1) wages, (2) premium. The distance *between* the dotted line and the thick line therefore represents *amount* of premium (or piece earnings) expressed in price units.

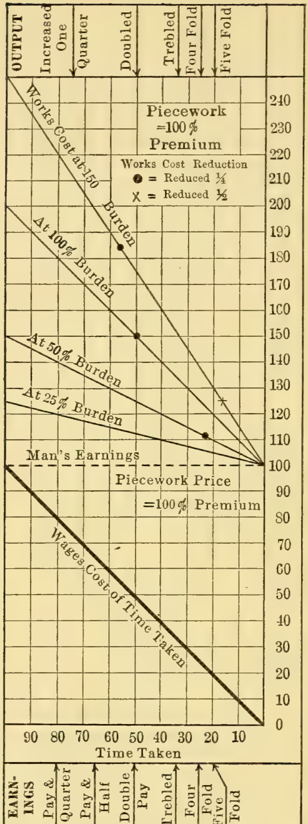
The fine lines represent *total works cost.* This is obtained by aggregating (1) time taken, (2) indirect expenses or burden on time taken, and (3) amount of premium earned. Several of these are shown, giving the different total works costs at different rates of burden, from 25 per cent to 150 per cent.

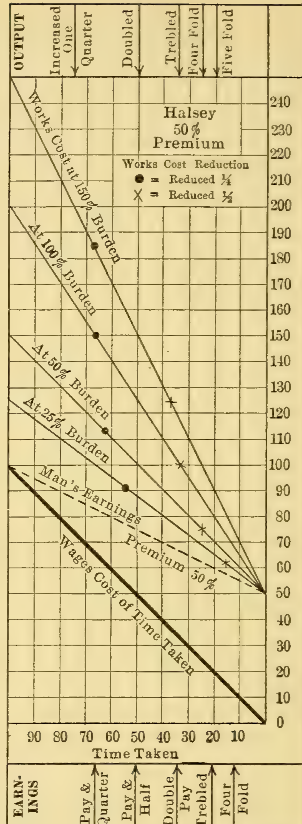
General Features of the Diagrams

The first thing that will strike the observer is the different degree of steepness shown by the lines representing total works cost. As this particular item is the real object of the employer's care, it is more important than the others. It will be seen at once, for instance, that each of the three methods presents peculiar characteristics. In the piecework diagram the lines tend more to the horizontal and terminate very high up (on the right-hand side). In the Halsey system they are steeper than in piece work, and go lower. In the Rowan system they possess about the same degree of steepness as in the Halsey, but tend to curve inwards as the time taken approaches a minimum, and they finally reach zero.

This steepness represents, of course, the rate of fall of total works cost, as less and less time is taken by the workman to carry out the job. It is a measure of the effectiveness of each system to produce the results wished for by the manufacturer, viz.: to reduce actual costs per piece. In each of the four diagrams it will be seen that the higher the burden of indirect charges, the steeper is the fall of works cost. But as between the systems there is much variation in the degree of this fall, and consequently in relative efficiency.

The second noticeable feature of the diagrams is the relation of the dotted line to the thick line. The distance between these two lines is the amount of premium or piece earnings at various "times taken". It will be seen at once how enormously the workman's share in piece work tends to increase as time is lowered; how in the Halsey system it tends to rise to a very much larger amount than direct wages shortly after production is doubled; and finally, how in the

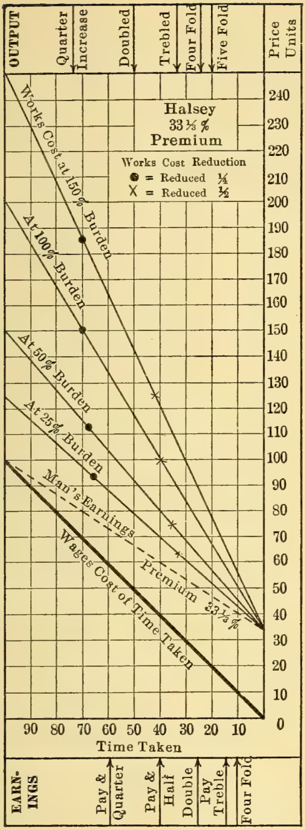


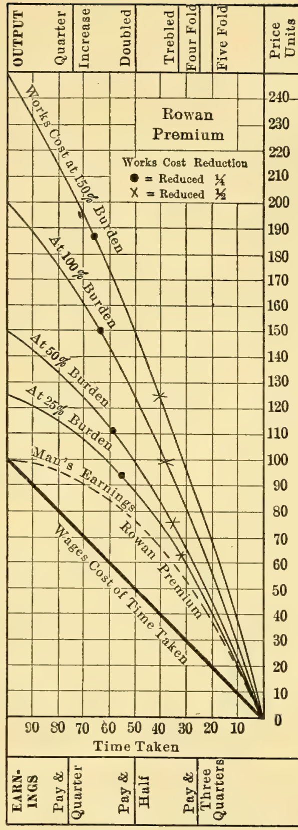


The Engineering Magazine

1. PIECE WORK   2. HALSEY 50 PER CENT

An allowance of 100 hours is assumed for the premium system, and an equivalent of 100 price units (wage hours) for the piece-work system. Diagonal thick line is wages cost of job. Dotted line shows total receivable by man—wages *plus* premium. Distance between thick line and dotted line on any vertical shows premium for the corresponding time. Fine lines show total works cost, made up of time taken, burden on time taken, and premium





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3. HALSEY 33 1/3 PER CENT   4. ROWAN PREMIUM

An allowance of 100 hours is assmued for the premium system, and an equivalent of 100 price units (wage hours) for the piece-work system. Diagonal thick line is wages cost of job. Dotted line shows total receivable by man—wages *plus* premium. Distance between thick line and dotted line on any vertical shows premium for the corresponding time. Fine lines show total works cost, made up of time taken, burden on time taken, and premium

Rowan system its ratio to wages rises steadily throughout, up to 99 per cent and not beyond.

A third feature of the diagrams is that whether the premium is 33 1/3, 50 or 100 per cent, there exists a "critical" point at which the works-cost line tends to diverge from, instead of approaching, the wages line. This always takes place when the rate of premium is greater than the percentage of burden. It affords an argument for low rates of premium, particularly in specialty departments, where the burden is low. It also affords a demonstration of the weakness of so high a premium as 100 per cent (piece work), because a smaller rate of burden than this is not infrequent, even in machine shops. Except with burdens considerably over 150 per cent it is practically impossible ever to halve works cost on this system.

The Rowan System

Before proceeding with a comparison of the data afforded by the diagrams, it may be desirable to give some details of the Rowan variety of premium payment. Although a writer* in the Engineering Maga-

* Mr. Carl Bender, Systems of Wages; The Engineering Magazine, December, 1908.

zine formerly stigmatized this system as "both fallacious and inhuman", it is included here because in the present writer's opinion it possesses important practical features which override any such hasty condemnation.

In the original Halsey system, the premium is based on our view of the facts of lowered cost; in the Rowan system a different view is taken. Mr. Halsey's method is, as already shown, a lowered piece-work rate of 33 1/3 or 50 instead of 100 per cent. Mr. Rowan's method is based on a different principle, viz.:—an increase of the man's pay proportionate to the reduction of the time allowance. Instead of saying to the man that he shall receive 33 1/3 or 50 per cent of what he saves, the Rowan system puts it another way. It says, in effect, that if he reduces time 25 per cent or 50 per cent, his pay shall be increased 25 per cent or 50 per cent or whatever other fractional reduction of time he effects. Comparison of the Rowan with the Halsey diagram shows that an important difference in principle is here involved. The premium area in the former is bounded by a closed curve. In the latter it is a constantly increasing segment. Inferentially, we see that in the Rowan system no possible error in fixing time allowance can lead to a man's earning double wages. It is this feature that Mr. Bender describes as "inhuman", but, as will be shown later, this strong expression arises from a confusion of thought between what can be done and what ought to be done on any system of payment by results. The object is not to enable workmen to earn double pay, but to effect two things: (1) incentive to increase production at the right moment and under the right conditions; and (2) a just and equitable distribution of the saving so effected.

Fallacies with Regard to Premium Systems

In distinguishing between the practical results obtained from piece work, premium, differential, and bonus systems, credit is frequently given to a system for something that has nothing to do with the merits of that system. This is well brought out in Mr. Bender's very interesting and instructive comparison of wages systems already referred to. In discussing the Taylor system, for example, it is said that "Mr. Taylor scorns the suggestion that by any chance the worker could earn excessive wages". This, we find, is based not on any peculiarity of the system, but on the premises that "the method of standard-time determination is so rigorous that the worker cannot figure on curtailing his output". The Gantt bonus system depends for its successful working on a similar rigorous time determination. In the Emerson efficiency system also, Mr. Bender says, "the standard time required for every job should be scientifically ascertained".

Now we have here *preliminary* conditions that are the actual controlling features of the situation. With very accurately determined standard times, it is perfectly obvious that the right-hand halves of all our diagrams could never come into use. Yet it is towards the middle and right-hand half of the diagrams that the difference between the systems becomes most marked. For small increases in production the variation in works cost between the different systems is comparatively small, and as everything in that case depends on incentive, it is quite an open question where burden is over 100 per cent whether the piece work system, with its 100 per cent premium, would not work out as well in practice as any other.

The success of a system which implies and necessitates a vigorous pre-determination of standard times or a close and careful study of routine operations, cannot be compared with the success of other systems of which the chief merit is flexibility and ability to meet unforeseen conditions. In the writer's opinion the Rowan system fulfils this last definition more completely than the Halsey, for as will be seen from the diagrams, it offers its greatest degree of incentive for moderate cost reductions, and one of its chief virtues is that for such exaggerated results as five-fold production, which can be due only to the absence of a rigorous determination of standard times, it protects the employer while still adequately rewarding the man.

The Piece-Work Diagram

Under piece work (= a premium of 100 per cent) the ratio of premium earned rises from 11 per cent for a saving of 10 hours up to a 900 per cent premium for the saving of 90 hours. It will be noticed that halved works cost cannot in practice be realized by this system. It only appears once on the diagram, viz., in the case of a 150 per cent burden, and more than five-fold production is necessary to realize it. In such a case the man would be obtaining a premium of 85 as against a wage cost of 15, or about 570 per cent. A reduction of one-quarter in works cost is only reached in practice at or about doubled wages, when burden is 100 per cent or over. It should also be observed that where burden is 100 per cent the works-cost line is parallel to the wages-cost line. Below 100 per cent they diverge, indicating that the rate of reduction in works cost is less than that of wages cost—also indicating a lessened efficiency just where the worker's reward tends to increase.

The Halsey Diagrams

Separate diagrams are given for 33 1/3 per cent and 50 per cent premiums. They present advantages over piece work just in the degree that the percentage of premium is lower. It will easily be seen (and it is a conclusive argument as to the real identity of piece work and premium in principle) that intermediate diagrams of 90, 80, 76 and 60 per cent premium could be constructed and they would show a *gradual transformation* from the horizontal price line of the piece-work diagram to the inclined lines of the two Halsey diagrams. The circles and crosses, representing one-quarter and one-half reduction in works cost, would also gradually enter and pass from right to left in successive diagrams.

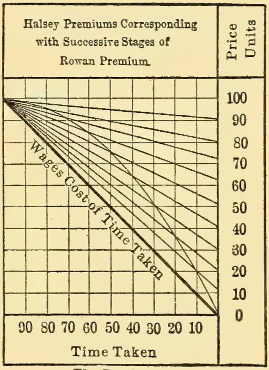
The principal point of interest in these two diagrams is in the fact that, by comparison with the piece-work diagram, they show the whole relation of higher or lower premium rates to the various elements of production, viz.: wages cost, man's total earnings, his share relative to wages, effect of increased production at different burdens, and the rate of fall of works cost relative to wages.

It will perhaps be unnecessary now to go over these points in detail because a comparative study of the diagrams themselves will reveal them, and their more important features will be summed up later. It may be remarked, however, that as in the case of piece work, where the burden rate is below the premium rate, as in the 25 per cent burden on either diagram, works cost does not fall as quickly as wages cost, although—the premium rates being much lower — the divergence is proportionately less. Under special conditions, however, this divergence might have a practical significance.

The Rowan Diagram

The closed curve of the Rowan premium rate is *really equivalent to a gradually falling Halsey premium rate.* This point is so important that a special diagram may usefully be introduced to illustrate it.

It will be seen that so far from being "inhuman", the Rowan system is actually more generous to the worker than a Halsey 50 per cent premium until wages cost *is halved,* and remains more generous than a Halsey 33 1/3 per cent premium until wages cost *is reduced two-thirds!*

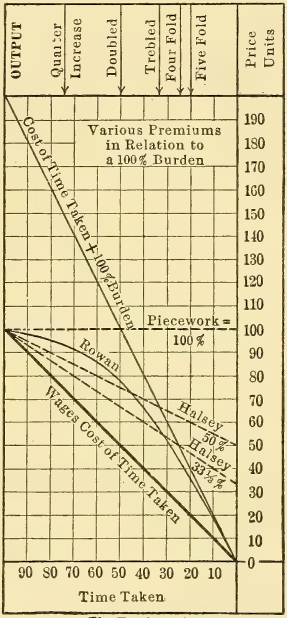


5. THE ROWAN SYSTEM

The radiating lines of the Halsey premiums corresponding to the various stages of the Rowan premiums do in fact exhibit, in practice, that gradual transformation from very nearly 100 per cent premium down to 10 per cent premium that was spoken of above, when it was said to be quite possible to construct a successive series of diagrams showing such intermediate stages.

The practical value of this variety of premium is that it provides incentive just where incentive is wanted, viz.: at the left-hand of the diagrams representing progress from full time to halved time. It has the further advantage that a considerable error in time allowance which would bring the wages cost well over into the right-hand side of the diagram, say for example up to the point of four-fold or five-fold production, does not disproportionately increase the man's earnings and render it necessary to cut rates, however great the error.

The point of view of the Rowan system presents other practical advantages which I believe are not realized on any other method. Where premium has replaced piece work, an atmosphere of dissatisfaction is not infrequently found, as soon as the men see that the employer is obtaining the lion's share of the saving. Very frequently they fail to realize that rates will not be cut, and indeed an examination of the diagrams will show that after a certain point there is just as much temptation to cut a high Halsey premium allowance, as a high piece-work price. Moreover, it is very well known to have actually been done. Under the Rowan method, however, there is no question of an unequal *share* of saving introduced at all. The Rowan proposition takes the form of giving the man an addition to his hourly rate *proportional* to the time he saves. If he saves a quarter of the time, he receives time-and-a-quarter; if he saves half the time he receives time-and-a-half. It is a positive merit of the system that it does *not* respond to the abnormal case propounded by Mr. Bender, in which one man is supposed to take half an hour and another 5½ hours to do the same job, because such a condition of things would be an absurdity, and would call for the prompt discharge of one of the men, and of the individual who fixed so wildly inaccurate a time allowance. A careful examination of the



6. HALSEY AND ROWAN COMPARED

diagrams will show that whatever merits the Halsey system has, the Rowan system preserves and adds others of its own.

Conclusion

The great aim of any system of cost reduction must be to reduce "works" cost. This is effected in different degree by each of the four methods selected for examination. Diagram No. 6 shows all four premiums plotted together on the same wages-cost line, and a 100 per cent wages and burden line added, *based on the fall of costs only,* without taking into consideration the premiums earned.

This 100 per cent line shows what would be the actual works cost (at 100 per cent burden) if the fall of cost *were wholly due to improved methods of production and not to the extra exertions of the men.* Obviously this is the ideal condition desired by the employer, and from a certain point of view, the necessity of paying premiums to effect this reduction is a necessary evil. By plotting the premiums between this 100 per cent line and the wages-cost line, we see how they bulk in each case, compared with this ideal (but of course unrealizable) fall in works cost. It will be seen that the piece-work line soon passes outside the 100 per cent line, that the two Halsey premiums follow suit one after the other, but that the Rowan premium never does. The whole significance of this diagram lies in the fact that 100 per cent is generally supposed to be, and often is, an average burden, and it is suggested that the points at which the various premiums cross the 100 per cent line is where the practical instinct of the employer begins to make him uneasy, and desirous of cutting prices or allowances. I do not wish to lay too much stress on this diagram, but it is certainly suggestive.

The practical deductions from the foregoing study of the four methods are not many but they are important. They are:

(1) That premium methods gain in importance precisely in proportion to the burden (that is, in proportion to the size and value of machines used, cost of power, handling machinery, high value of land or buildings, expensive nature of supervision, *etc.*).

(2) That where *very accurate time allowance* can be thoroughly depended on, the system which gives the sharpest fall of works cost is, other things apart, the best. This

condition is fulfilled by Halsey 33 1/3 per cent, in which the fall is sharper than Rowan until wages cost has been reduced between ½ and 2/3—an event not likely to happen if time allowances are accurate. But this consideration is influenced by the question of incentive. For the same time allowance, the incentive to reduce cost is greater under both piece work and Rowan system than under Halsey in the earlier stages. As it has been proved over and over again that added incentive (raising of time allowance) has proved the key to unlock the workman's ambition, the advantage of Halsey over Rowan is perhaps doubtful. If the man can be got to work equally energetically under either plan, then under the Halsey plan works cost falls more sharply, but as the Rowan plan, for the same time allowance, provides a larger incentive (and therefore a slightly higher works cost) its effect on the man is presumably greater. In the case of very accurate time allowances, therefore, there seems to be a certain balance of advantages between the two methods.

(3) Where time allowances are not scientifically and very accurately determined, then there can be no question which method has

the balance of advantages. If the determination is very bad, then the Halsey premium, even when as low as 33 1/3 per cent, gives the man a wholly disproportionate share if he reduces the nominal time to its real working value. On the Rowan plan the falling premium rate automatically compensates for such errors, while still giving the worker a fair reward for extra effort. (The point at which the premium lines pass outside the 100 per cent lines in Diagram 6 illustrates this aspect of the question.)

(4) For very low burdens, such as 25 per cent, only realized, of course, in very special work, a very small Halsey premium not exceeding the ratio of burden would perhaps lead to the most efficient results. The Rowan system does not seem to be adaptable to very small burdens, because the lines of its very high premium rates at the beginning diverge very greatly from works-cost fall. It is only with burdens of 75 per cent or 100 per cent and over that the best efficiency can apparently be obtained from the Rowan system.

Generally speaking, the results of this examination go to show that the merits of any system of premium payment are a balance between incentive and actual steepness of fall of works cost. Naturally, the nearer works cost approaches the ideal line in Diagram 6, the better. The best premium is that which raises this line as little as possible. Obviously, two considerations are involved: (1) Enough must be offered to effect the reduction in the first place; (2) it must not be so much as to make the resulting line as flat as is shown in the case of piece work. As a purely abstract statement, it may be said to be just as little as the worker can be induced to accept, and yet keep his energies directed toward reducing cost further and further. This is the economic statement of the plain truth, but like most economic statements it has to be considered alongside human nature and with human sympathy before it becomes other than an engine of discord and strife. Of the four systems examined, the Rowan system seems to prevent, in practice, any arrival at a point where the interests of employer and employee come into actual conflict. It either produces or fails to produce sufficiently satisfactory economic results. In neither case does anybody lose; they only fail to gain. There is a psychological difference in that which has important practical bearings, and makes for industrial peace.

And a remedy can generally be found, where interests do not drift into antagonism at any stage of their relations.

In the present chapter those systems of payment for labor are alone discussed which depend upon a simple time limit and sharing-out of the savings effected by the reduction of this nominal limit. A subsequent paper will deal with the relation of burden to "task" or "bonus" systems in which the worker's benefit either commences or is greatly increased at a predetermined point, and the success of the system in practice depends upon the proportion of workers who attain or pass this point. As this involves quite a different point of view from ordinary piece work or premium, it must be made the subject of a separate discussion.

Appendix III

THE EXPENSE BURDEN IN RELATION TO BONUS

IN Appendix II, those systems of payment were discussed which depend upon a simple time limit and an equally simple law of apportionment of the reduction made. In this chapter, the newer and more complex "task" or "bonus" methods will be reviewed in the light of their bearing on works cost, *i. e.,* prime cost *plus* expense burden.

The two principal methods are the Gantt Bonus Method and the Emerson Efficiency Method. It is necessary to treat these two systems of remuneration from a different standpoint from that adopted for the examination of the others, inasmuch as they are the outcome of what might almost be looked on as a new philosophy of manufacture—a revolution which is, however, really a return to first principles, viz., a close watch on the duration and circumstances of every successive operation in a process of manufacture, with a view to determining a theoretical maximum of productive output. It is curious to observe that the scrutiny of successive operations with this end in view was more familiar in early days than in later times. In Babbage's "Economy of Manufactures", published in 1832, hints are given as to the precautions necessary in timing the details of operations.

It must be perfectly evident to every sober-minded observer that the ultimate success of piece work, using that term in its broadest sense to indicate all kinds of remuneration by results, must depend upon the possibility of finding ultimate or "real" bases for calculation. The objections to piece work on the part of trade unions is founded on the perception that, as at present fixed, all prices are to a great extent arbitrary. When they are offered, there is no possibility of judging their fairness except by trial and error, or by the exercise of that very delusive quality, the practical man's judgment. This, by itself, is no great matter, but it becomes overpoweringly important in relation to the perennial bugbear of the relations between capital and labor—the cutting of rates, or, what is even more dreaded, the gradual whittling-down of rates.

In engineering manufactures, the enormous variety of pieces in shape, size, weight, and material, and the great number of different processes which can be and are applied to any one piece before it is finished, render "standard" price lists of pieces impossible. Consequently as matters at present stand there is some degree of reason in the attitude of trade unionists towards piece work. Even though as regards any one shop there may be a fair and square understanding that prices, once fixed, shall never be reduced, that (in itself difficult to attain in practice) is no safeguard against other firms in the same line fixing slightly smaller prices—a process which has a tendency to continue in spite of the efforts of the better class of employers, and the theory that the best workmen will always gather round them.

Up to the present time all systems of piece remuneration must be considered as temporary and practical solutions of a problem of great importance — involving a certain amount of dissatisfaction at times, but kept working by the common-sense and fair dealing of the parties to the bargain. The special interest of the task-and-bonus methods is that they are a considerable step forward towards a state of affairs when most piece-work prices will be referred to an ultimate or real basis and thus be beyond dispute, either at different times in the same shop, or at the same period in different shops; not because of the peculiar methods by which payment is reckoned, but on account of their minute survey of the maximum possible production, and their enumeration of every factor occurring in such production.

It is perfectly obvious that these new methods are leading up to an ultimate basing of prices on these known factors. For though these factors are numerous, they are not infinite in number, and it is only a matter of time before they will become tabulated so that the price of any new piece of work will be a simple aggregate of the prices of its factors. When this desirable stage has been reached, the settlement of standard prices for these factors between employers as a class and workers as a class will become quite feasible, and a much higher degree of industrial peace will have become possible. The progress made of late years shows that this is no fanciful picture, but a sober possibility. It seems certain, therefore, that the best interests of trade unions would be furthered not by blind opposition to every kind of piece work, but by an intelligent and friendly co-operation with all attempts to continue and extend the work of finding and standardizing the unit factors of operative production.

The Gantt method of piece remuneration consists, in essence, of what may be termed a truncated piece-work price. It sets back the time limit in such a way that the early stages of increased speed on the part of a worker do not yield him small results, but no results at all beyond his ordinary day wage. On the other hand, when this increased speed has, so to speak, acquired sufficient momentum, and has attained a certain predetermined efficiency, the worker finds himself in possession, all at once, of a substantial reward, the proportion of which, relative to his day wages, continues to be an increasing quantity as long as he continues to reduce the allotted time. In the Gantt method a time limit, or allowance, is set as in all other methods of payment by results; and precisely as in ordinary piece work, any reduction of this limit goes entirely into the pocket of the worker.

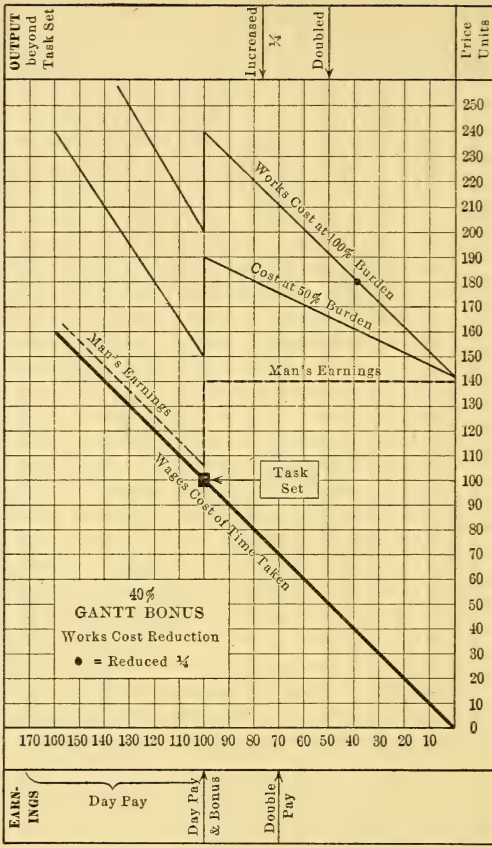
Thus if a task of 14 articles per day be set and the worker receives $2 a day, day wages, then for 10, 11, 12 or 13 articles he receives day wages, but on attaining 14 articles he begins to be paid the bonus of (say) 40 per cent, making the equivalent of a piece-work price of 20 cents each, thus jumping to $2.80 per day.

This piece-work price is arrived at normally by adding 40 percent to day wages, and dividing by the number of pieces determined on as a fair task; thus $2 day wage, plus 40 per cent, is equal to $2.80, which divided by 14 pieces gives $0.20 for each piece. If he produces 15, 16 or more pieces, instead of 14, he receives 15×20=$3.00, or 16×20=$3.20, *etc.*, for his day's output. In other words, the task price once attained, becomes an ordinary piece-work price and all saved goes to the man.

In all other systems hitherto examined, the passage from day pay to extra earnings is smooth and gradual. Whatever premium or reward is paid to the worker is given for reduction of a time limit, and is in strict proportion to the amount of that reduction. The only difference between those systems is in the relation of the reward of extra effort to the total works cost of the job. And this difference is mainly one of degree. As regards the worker their influence is also very similar. When he attains the limit set, his profits begin, and it is open to him to be content with any degree of profit, large or small, according to his ambition. The time limit set can hardly be described in such cases as a standard attainment, but rather as a milestone, because immediately on either side of it his earnings are much the same, and it is only gradually that they increase when he has passed it.

In the method we are now discussing, *the milestone is set at the top of a hill, and a considerable reward is given for getting up to it.* It is true that an increased reward follows for further progress, just as in the other systems, but that is not the principal object in view, which is to set a standard of attainment and not a starting point. Examination of the diagram (page 464) shows the peculiar feature of this system very plainly. The dotted line, representing actual earnings, corresponds with time taken until the task or limit is attained, when it rises suddenly, and continues to diverge from the time-taken line, representing an increasing rate of profit or earnings, as time is reduced.

Various interesting deductions can be



The Engineering Magazine

7. EFFECT OF GANTT BONUS SYSTEM ON EARNINGS AND WORKS COST

An allowance of 100 hours is assumed for both systems. Diagonal thick line is wages cost of job. Dotted line shows total receivable by man—wages *plus* bonus. Distance between thick line and dotted line on any vertical shows bonus for the corresponding time. Fine lines show total works cost, made up of time taken, burden on time taken, and bonus.

made from a study of the diagram. In the first place, the meaning of the phrase "a truncated piece-work price", used above, will be made clear. It is obvious that if the dotted line representing earnings were continued right across the diagram so as to meet the line of time taken, this diagram would be precisely equivalent to a piece-work diagram with a time limit of 140 price units. Regarded from this point of view, the Gantt system is a method of holding back the early portion of profits due to increased activity, which on an ordinary piece-work plan would, from the beginning, go to the worker. This is confirmed by the works-cost curves, which fall sharply until the task set is attained, then rise suddenly, and fall again at a slower rate than before, owing, of course, to the inclusion of extra earnings in them. They are precisely equivalent to piece-work cost curves, except that the latter fall regularly without either the preliminary swift descent, or subsequent restoration to the normal by the sudden rise.

The bearings of the Gantt method on works cost and production generally must now be discussed. As regards expense burden, the principles worked out in the previous chapter when dealing with piece-work systems apply to the Gantt method also. The maximum effect on works cost (labor cost *plus* burden) occurs with high burdens. It is not until 100 per cent burden occurs that works cost begins to fall parallel with wages. At first sight therefore it would seem to be less economical than the premium plan.

But in looking at the results of the Gantt system as shown by the diagram, it must be borne in mind that this method sets a standard of attainment and its *raison d'être* is largely fulfilled when it has been attained. Consequently *the curves on the right hand of the diagram have very little importance*—much less importance than those in corresponding positions on the diagrams of the other systems. The time limit or task is so set that *most of the impulse given by the method takes place before and not after the limit is attained.* Hence on this system the determination of the task is all-important.

In Mr. Gantt's book on "Work, Wages and Profits",* which must be regarded as one of the most important contributions yet made to the subject, the philosophy underlying his method is brought out in detail. If there is

* Work, Wages and Profits by H. L. Gantt, Second Edition, 1913.

one thing more evident than another it is that the mere mechanism of reward—that is, the part of the method capable of being expressed in a formula or a diagram, is the least essential portion of it. This is very important to understand and to remember, because the temptation to identify the method with the mechanism of reward is necessarily great. But to install the bonus or task-limit system without the rest of the method would be to court disaster on a big scale. Of all the systems of remuneration yet examined, the Gantt is the most dangerous in the hands of the amateur organizer, who is unable to view manufacturing operations as an organic whole.

The ultimate object of all these systems is to secure a reduction in works cost by providing some method of stimulating labor. In all the systems previously examined, this object is attained in a more or less empirical manner. No definite standard is in view at any time. The principle frequently recommended to those installing the premium system, *viz.,* to be generous with the time limit and parsimonious with the share or percentage of division, is a wise one in the majority of cases and represents a cautious advance into unknown fields. Where this principle is adopted, the consequences of an error in the time limit are not very serious, and are, indeed, reduced to a minimum on the Rowan system with its closed curve of share percentage. On the Gantt system, however, an entirely new principle comes into play, and the mechanism of the system, though peculiarly adapted to its necessities, is quite secondary in importance.

The special and admirable feature of the Gantt method is that it commences by an inquiry into the possible maximum of production, and uses the information thus gained to set up a standard of attainment, difficult perhaps, and in fact impossible to the *unaided* worker, but just for that reason more than ordinarily valuable because it enforces the necessity and develops the faculty of intelligent and successful co-operation. All the previously examined systems confine their attention to the operative and work on the supposition that by the promise of extra reward his movements will not only be quickened, but his intelligence aroused. That is unquestionably the case, but how much they will be quickened or aroused is left entirely to chance, for the very good reason that no one has known (except the all-wise rule-of-thumb and judgment man) what possibilities were in sight.

It is, however, very much easier to determine a theoretical maximum of production than to guess at what is "a fair day's work". Given certain conditions, there is always a limit (and it is a mere matter of observation and calculation) beyond which production cannot possibly pass. But in determining this theoretical maximum, it is quickly seen that its attainment depends on a number of auxiliary conditions whose importance — whose vital importance — is otherwise apt to be neglected. This is precisely the point where the "magic touch" comes in, where the subtle difference of principle begins to have important practical results.

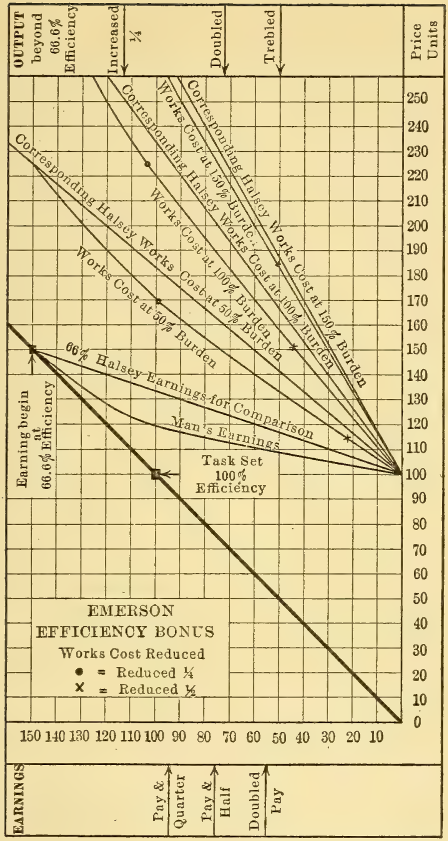
The older systems stimulated production, and were well content when they had done so appreciably. As there was a good deal of "trial and error" in their methods, they were very apt to rest on their oars when some progress had been made. In fact, too much progress became rather alarming as individual items of the payroll approached the point of "double pay". When a certain percentage of increase had taken place, everyone, whether master or man, was inclined to say ''good enough'', for want of knowing any better.

But the moment that a theoretical standard of maximum production is set up, everything is changed. It is an ineradicable factor of human nature to struggle towards a definite ideal—the real trouble of life being that few of us get hold of the right ideal. This applies quite as much in the prosaic atmosphere of the machine shop as anywhere else. The inevitable result of discovering a tangible goal, a maximum standard of attainment, is that only the lazy and incompetent will be willing to rest on their oars after a short spurt of advance. Instead of everyone exclaiming ''good enough,'' the tendency will necessarily be for everyone to exclaim ''might be better''. The stimulation which the older methods apply to the workman alone is shared by everyone concerned, and, what is most important, a much more intelligent appreciation of the whole of the conditions — main and auxiliary — pertaining to successful production will be aroused. Incompetence necessarily has a rough time when it is visibly holding back progress towards a definite and ascertained goal. It will be seen, therefore, that the psychology of the Gantt method is much more important than its mechanism.

It is true that so far all the progress that has been made is towards standardization of actual machine work—towards ascertaining the theoretical maximum output of the machinery and labor in conjunction. Yet, the relation of expense or burden to production is one of the most serious problems in the attainment of a minimum works cost. It is, perhaps, inevitable that the importance of setting up definite standards of operative work must be recognized before the importance of standardizing indirect expense can be driven home. But no one who is familiar with the question can fail to perceive that the new view of production given by Mr. Gantt lies in the same straight line with the "production-factor" method of dealing with expense burden advocated by the present writer. In wholly independent fields they both tend towards the same end, and that is the predetermination of theoretical efficiency. The tendency in both is to consider each machine as a "production centre" and thoroughly to discuss, enumerate and record all the conditions of its maximum successful operation. They both seek to set up definite standards of work, by which the efficiency of all similar machines wherever placed can be judged.

Obviously this is no mere chance coincidence. It represents the existence of a very definite trend in principles of administration, inevitable as manufacturing operations grow in scale and complexity. It marks the introduction of a higher order of intelligence into manufacturing operations, viz., the co-ordinating as apart from the merely directive, the staff officer as distinct from the regimental commander. There is no getting away from this. The principle of prevoyance, of accurate predetermination of the powers of production in all their aspects, has come to stay.

In this field the work of Mr. Harrington Emerson is also well known. Here again we find a system of payment of a peculiar character which borrows its importance from its association with a standard of theoretical efficiency. The main difference between the Emerson and Gantt systems lies in the nature of the curve traced by the "earnings" line. Whilst the latter partakes of the character of a "truncated" piece-work limit, the for-



8. EFFECT OF EMERSON WAGE SCALE ON EARNINGS AND WORKS COST

An allowance of 100 hours is assumed. Diagonal thick line is wages cost of job. Earnings line shows total receivable by man—wages *plus* bonus. Distance between thick line and earnings line on any vertical shows bonus for the corresponding time. Fine lines show total works cost, made up of time taken, burden on time taken, and bonus mer (see page 473) is a 66 per cent Halsey limit, pure and simple, at the beginning and end of its operation, but between these, forms a parabolic curve (of which the likeness to an *inverted* Rowan curve will be noticed) corresponding to a whole range of Halsey limits as the actual time taken is reduced. The practical effect of the parabola is most noticeable in the earlier stages of time reduction, allowing only an almost negligible bonus until the nominal limit called 100 per cent efficiency is being approached.

In the Emerson system, also, the curves on the right-hand side of the diagram possess comparatively small importance. The whole field of operation is supposed, as an axiomatic condition of the adoption of the method, to be so exactly mapped out that no great reduction of the task set is likely. The psychological difference between the two methods lies in the absence, in the Emerson system, of a sudden rise in earnings. On the contrary, earnings begin to grow when two-thirds of the task efficiency has been attained, although very slowly in the earlier stages. The question naturally arises — which of these two methods of approaching standard efficiency is best?

No definite answer is possible, or rather any attempted answer must contain several unknown or indeterminate factors. Personally, the clearness and definiteness of the Gantt standard seem to me to offer a greater leverage on average human nature than the gradual rise of earnings on the Emerson method. But in actual practice everything depends on the personality of those who are in authority—much more perhaps than on the workers themselves. Probably the Gantt method requires greater self-confidence and a clearer survey of the ultimate goal to be reached than the other, but just because of its definiteness one may be inclined to suggest that in the right hands its success would be more thorough and uniform.

Considered in relation to high burdens, it will be seen from the curves that the Emerson works cost does not differ to a very great degree, at any point, from an ordinary 66 per cent Halsey premium works cost. The higher the burden, the closer this approximation becomes. The practical deduction from this observed fact is that the principal value of these new methods of remuneration lies in their introduction of the "Standard of

Efficiency'' idea—that is, their placing of the task milestone at the top of a hill, and thus setting free the tendency inherent in all humanity to attain, if possible, a goal that is in sight.

In the foregoing examination of these two methods nothing has been said about the remuneration which is given to other than direct-workers for attainment of task or standard efficiency on the part of these latter. Yet it will be obvious that bonuses to officials whose intelligent and active co-operation in their respective spheres is necessary to enable the worker to have an uninterrupted chance of success, is a most important feature of these advanced methods. Such bonuses are not new in themselves, but under the older methods of working have rarely been found satisfactory, leading, not infrequently, to aggravated forms of ''driving'' and general unrest. It is only when introduced as part and parcel of the standard efficiency or task idea that they promise success, because, and only because, the introduction of this idea leads to production being regarded from a co-operative point of view, in which manual skill, machinery and directive (or rather educative) effort, have each their appointed place. In other words, the bonuses are given not for "making" other men increase their production, but for "helping" them to do so—a very different ideal, signifying entirely different personal relations and a much more progressive atmosphere.

It has been shown above that, in relation to burden or establishment charges, these new methods of remuneration do not present any strikingly novel features; that is to say, they do not introduce any new relationship between the time actually spent on the job and the overhead charges the job has to bear. Nevertheless the introduction of the standard task or efficiency idea may have, as already briefly pointed out, an influence on the point of view from which burden is regarded. For if we assume a standard task and agree to regard any failure to perform it as so much avoidable inefficiency, it is evident that we imply a standard quantity of burden, whether the latter is regarded as a percentage of time, or wages, or is treated on the "production-centre" system of machine rents. There is, then, a double degree of inefficiency in failure to come up to standard on any job. Not only is there a loss of time, but what is sometimes even more important, there is an undue absorption of burden. The modern principle of predetermination of standard time-cost requires to be supplemented by similar standardization of overhead burden, in order to bring all the elements of cost to a focus.

The inefficiency of a shop may take three principal directions, viz.:

(1) Wasted burden owing to idle machinery.

(2) Wasted time due to standard tasks not being attained.

(3) Unduly absorbed burden on this unnecessary time.

Items (2) and (3) are of course inseparable, and vary together. The question is complicated by the fact that while (2) is an obviously unnecessary expense, (3) on the other hand is a false *credit;* i. e., it represents an amount by which burden, chargeable either against the shop or against the machine, has been improperly relieved.

Space does not admit of a fuller discussion of the general relations of burden to costs under a system, such as the Gantt or Emerson, of standardized task efficiency. Enough, however, has been said to show that the subject requires development if only because the *mechanism* of both systems shows no changed relationship of time to burden, although the *spirit* of each system really changes such relationship entirely. In other words, predetermination of standard costs, depending as it does on the close application of scientific methods of analysis of the elements of jobs, and the consequent accurate mapping out of all the field of production, throws, to a considerable extent, the relations of burden to cost into the melting pot. For it is obviously an incomplete programme to have one-half of productive expense accurately surveyed, and to leave the other, and possibly the larger half, on the old haphazard basis.

At the outset of this inquiry the question of equivalent time-limits on the different piece-work, premium and bonus systems occupied my attention. It is actually possible, and seemed useful, to determine these equivalent limits, which promised to afford a method of switching over from one system to another. Further examination has shown that though this is to a great extent possible, e. g., every Gantt limit at a given rate of bonus has an equivalent Halsey limit at a given rate of bonus—nevertheless to lay any stress on this point would be mischievous and misleading. For as already remarked, the mechanism of the new methods is their least important feature, and to offer any details which might lead the unwary to think of adopting the mechanism without the far more essential spirit, would be a poor service.

The moral to be drawn from an inspection and comparison of the diagrams in this and the preceding article will now be recognizable. It is that between all these systems of remuneration there is a strong family likeness, and that there is not between them as great a difference in principle as is commonly supposed. Fundamentally and in all essential points, they attain closely related results by very similar paths. The differences between them resolve into the shifting backwards and forwards of time-limits and tasks, and the greater or less share which is retained or given as a reward for extra exertion. After a dispassionate examination, the closed curve of the Rowan system with its self-protection against the results of bad errors in limits seems to me to offer many advantages—considered merely as a *mechanism* of reward. On the other hand, the newer method of standard task or efficiency examined in the present article must in time supersede all others as to *principle.* The question arises, however, whether some combination of the Rowan closed curve for mechanism, with the standardizing idea as principle, is not possible, and if possible whether it would not form a happy and practical combination. Investigation along this line seems worth while.

APPENDIX IV

THE PLANNING DEPARTMENT

THE term "Planning Department" is a comparatively recent coinage, but most of the functions that it exercises are not in themselves new, though it is claimed that they are rendered more efficient by being joined under one roof. On the other hand, all of them are not necessarily present in any given plant.

The magnified importance attributed in some quarters to the planning department arises from non-appreciation of the fact that it exercises three entirely different functions, which have no necessary dependence on one another. When all these important functions are called by the same name, it has necessarily rather a formidable appearance. It is in fact a kind of department store selling different goods at separate counters. Such a store looks imposing, but in essence its operations are no different from those of the little corner store.

In its most involved form the planning department is engaged on work that properly belongs to the drafting room, some that pertains to a rate-fixing department, and the remainder to a stock-tracing department. Neither of these departments, taken separately, is capable of running the plant without other assistance, and it is difficult to see how the united wisdom of all three, even if combined within the same four walls, can do more than settle the method of doing work, fix a price for it, and keep the stock moving. There is no *prima-facie* reason why these three functions are any the better for being centralized, and called by one name.

Whatever doubt one may feel is increased by observing the order in which these functions must be exercised on any piece of work. They are in no sense simultaneous, but strictly independent. Thus we have:—

(1) Settlement of what processes are to be performed. This is obviously antecedent to anything else, and as has been pointed out in these pages, ought to be a question arising during the designing of the piece.

(2) Settlement of the piece-work price to be paid for doing the work. Whether based on time study, or a shrewd guess, or by the ordinary method of comparing with some

similar piece, this function seems quite self-contained. It does not even matter whether the piece is ever made or not, much less how it is despatched or traced—the piece-work price would be just the same.

(3) The processes having been determined on and the rate being fixed for each, the only remaining thing is to get it made. This is a pure matter of securing material and instructions, marshaling, despatching, or tracing, and its ease or difficulty depends on the definiteness with which the sequence of processes was determined in the first place. It has nothing to do with the piece price, because it might all be day work equally well.

These three functions having, therefore, well marked border lines—what is gained by massing them together and calling them a planning department? This is so important a matter that it demands a separate discussion in this place.

Planning is, in essence, the exercise of foresight. Specifically it consists in adjusting the relations of things before they happen. In this sense, almost every business step involves planning in some degree. The planning of buildings, of the product, of the various kinds of machines we propose to use, of the different kinds of labor we are to engage—all these are examples. But in this chapter we shall consider planning in the more restricted sense of regulation of production.

Very brief consideration of the subject will show that planning must be a very elastic term. The methods that would be appropriate to a machine works, handling thousands of parts as to variety, and millions as to number, such parts running through perhaps ten to twenty processes each, would be totally inapplicable to a textile mill or a shoe factory, because it must be laid down as a prime rule for planning systems that *they must not develop more complexity than the needs of the case require.* Where there are only two alternatives to action, we do not require such complex mechanism to control it as when there are twenty alternatives.

A second principle, worthy of careful observance, is that planning systems should be staffs and not crutches. They should not tend to crush self-reliance and initiative, and reduce everyone to a mere pinion in a machine. They should be in the nature of sign-posts pointing the way, but their usefulness should not be stultified if by any chance it is impossible, for some unforeseen reason, to take that particular way.

These remarks are necessary because in some quarters it is supposed that planning is a new art, based on newly discovered principles. This is erroneous. It is only the name that is comparatively new—the functions exercised under this new name are not at all new. No new principles of any large importance have been developed of recent years, though particular combinations of the planning function have been put forward and wide claims made for them. The fact is, however, that no combination has any preeminent value — *the planning arrangements suitable for any particular business are really among the most thoroughly individual kinds of organization that can be imagined.* For this reason we shall refrain from describing any one combination, but confine our attention to trying to indicate the normal principles underlying the function of planning, or controlling the course of production.

The evolution of the component or part (where a product consists of components that are made separately and afterwards assembled) begins in the drafting room. In many industries, of course, there is no drafting room nor anything corresponding to it. The shape and treatment of the product are determined not by sketches on paper, nor even by models, but by the design of the machinery, as for instance in cotton spinning. In such cases, this first stage of planning really is transferred to the machine itself and embodied in it. Where machines will only do one thing and do it in one way, it is evident that this first stage in the evolution of the assembled part must be wholly missing. But in most assembling industries the first stage is that of a design on paper or a model of the actual article.

As has been already suggested in former chapters the process of designing the component offers the great field for foresight. It is here that our more or less intelligent planning will make the greatest economic difference. The drafting room is sometimes claimed to be the brain of the factory, but it does not always succeed, and in many cases is not permitted to succeed, in being as wise a brain as it might be. The fault, however, generally lies not with the designer but with the traditions of the plant.

As a general principle the more complete the consideration given to the component at this stage of its career, the less will be the necessity for complex arrangements at a later stage. But the amount of consideration that it is possible to give usefully will depend entirely on the nature of the industry—that is, it will be in proportion to the number of alternatives which will be presented during the processes of manufacture. In the simpler cases, say for example the manufacture of a switch, there is very little opportunity for the exercise of foresight, beyond the designing of suitable press-tools, and the selection of stock patterns of such things as screws, handles, pins, etc. For the rest, it is probable that the use of certain machines will be indicated by the form of the tools provided, and no alternatives of operation can arise in the shops. In such a case it is obvious that elaboration of planning details would be foolish and economically unsound.

The opposite case to this is that of a factory making a product, say for example a typewriter, consisting of a very large number of parts, many of which go through a long series of processes, and some of which may be manufactured in several different ways. The case is still further complicated where there are several varieties of some of the parts, all very similar in appearance, yet not precisely alike but demanding differences in processing at some point of their career.

Let us consider what this complexity of product actually signifies in relation to the possibility of planning our operations in advance. In particular we must keep in mind the desirability of separating the problems of Division of Effort from those of its subsequent co-ordination. To confuse or mix these is to introduce needless confusion.

As has already been shown, design really has two independent aspects—design for use, and design for economical manufacture. These may sometimes clash, in which case the former aspect necessarily dominates. But in a general way much good will come of an attempt by the designer to keep the method of manufacture steadily in view whilst the shape and material of the piece are germinating in his mind. The possibility of economy at this stage, again, will depend on the existence of alternatives. If the piece must be of a certain shape and dimension, and of a particular material, there is nothing more to be said on that score, but in how many instances is this absolutely the case? It more frequently happens that there is at least some latitude in one or other of these respects, and a very slight modification of design may mean all the difference between difficult chucking or holding, simultaneous or separate drilling, hard or easy access of the tool and so forth. Even where the conditions are absolutely prescribed by use, a lug or ear added to the design for subsequent removal may make all the difference between costly handling and the reverse.

These are merely instances of the kind of foresight that is possible to the designer. They might be multiplied to any extent, because it is or should be the duty of the designer to picture to himself, not only the finished component, but the same component at all its intermediate stages of manufacture. In no respect is this more necessary than in regard to specifying the necessary degree of accuracy in machining, a subject much neglected, and of which the neglect is extremely costly. To issue shop drawings without specifying limits and fits is either to cause unnecessary expenditure in attaining unnecessary refinement, or is prolific of costly hand fitting, and spoilages.

In modern manufacturing the design can

hardly be said to be complete unless the necessary jigs and fixtures to promote its manufacture are considered at the same time. Frequently this branch of work is separated from design of components, and placed in the hands of a separate department, or in a so-called planning department which is considered as more distinctively a "shop" department than the drafting room. This seems a distinctively retrograde step, and the first stage on the path to needless complexity of organization and routine. Design in all its branches is an entirely separate class of effort from manufacture. It cannot be too rigorously kept as such. The place to apply cool and deliberate consideration of all the elements of a component, including the question of how it is to be made, is within the four walls of the drafting room. Only there can necessary modifications be wrought into the design, till it emerges as well adapted to its purpose, viz., to get made as cheaply as is compatible with its subsequent efficiency of use.

The question where the function of design begins and ends is one of the first we must ask, *if we are to keep it clear of the other forms of activity.* Briefly, it begins with the designing of the component, and should end with specification of the way to make it, including the subsidiary design of all jigs and fixtures, and the clear statement of all limits and fits. This conception of a design may be likened to that of a kite with a long tail. The great triangular body of the kite is the important thing, but the subsidiary pieces of its tail are necessary to enable it to fly. The kite is not complete without the tail. Similarly, before we get perfect flight we may have to modify the tail pieces, and even to trim the body itself.

Designs are rarely perfect creations from the first. Defects may be obvious, or they may not be disclosed save through experience. This applies both to the design for use and the design for manufacture. Our main body—the shape and dimension of the piece itself—may not be capable of improvement; yet the tail, that is, the pre-arranged methods of manufacture, may be discovered to be susceptible of advantageous change.

What does this suggest?

It suggests (1) that the drafting room should be in closer touch with the shops than is common at present, and that one or more of its members should be expert in production; (2) that where repetition work is in question, each design should be tried out and tested, and if necessary sent back for modification by a special department attached to the drafting room, before the design is finally adopted and embodied in standard shop instructions. This checks the design for efficiency of manufacture, as a drawing is checked for various kinds of errors before it leaves the drafting room.

In many industries all the foregoing may be taken for granted. The design and the method by which the article will be made are so intimately connected that one implies the other. In designing a shoe of a certain type the whole range of machines and processes that will be necessary are implied in the design. There is very little choice in the matter. Perhaps the larger half of industry is in this position, the planning problem being thereby greatly simplified, and the fundamental error of trying to tie up some of the functions of design with those of organization in a "planning department" is less likely to be made. For, when the design and all its accessory implications such as jigs, fixtures, and methods of manufacture are settled, planning becomes simply a question of co-ordinating the flow of work and the instructions.

It is sometimes claimed that an important part of the work of a planning department is the supervision or at least the checking of the "feed and speed" of the machines employed. Except as an attempt to introduce complexity and make the planning department take responsibilities that do not belong to it this does not seem an advantageous move. It is an idea that could only have arisen in a machine shop. That it has ever been attempted is attributable to the ignorance of machine capacity so universal in machine shops, but in my opinion the remedy is at least as bad as the disease. In many industries the necessity does not arise, since the speed of machines is either not variable at all, or only within limits well understood by every one handling them. No one would dream in such cases of writing out elaborate "schedules" to control machine operation. In machine shops the remedy for improper speeds and feeds, as pointed out in a former chapter, is not an attempt to control them from an office, but a close shop study of the properties, capacities and duties of machines and a generous training of the shop operatives in this elementary but much neglected branch of their proper work.

Relegating the control of "feeds and speeds" to where they belong, viz., to the shop itself, and considering the design of components as what it truly is, viz., a wholly independent field of effort, we are left, as stated above, with co-ordination of the flow of work and instructions, as the normal and real field of what may be called "planning" —that is, keeping things moving in an efficient way. This question has been so fully covered in previous chapters that but little remains to be said in amplification.

In every industry, good store-keeping control is the first thing to be secured. It does not so much need to be elaborate as to be *thorough*. That is to say, that complex card indexes and mnemonic symbols of alarming complexity are not so important as competent men to handle, price, issue and watch the multitudinous details of which store-keeping is often made up. Very frequently the store-keeping department is starved of good men, and this is particularly the case where executives have absorbed the idea that "system" will run a plant by itself. No economy is more foolish than this, since incompetent store keeping can not only bring about direct loss, but by failure to have on hand the stipulated stocks may derange and tie up important orders. The store keeper should be more than a bright clerk; he should have more than a passing acquaintance with the trade, or with the lines of product handled. Otherwise inventories will generally be found to be unsatisfactory, and the nicely written "records" full of farcical absurdities when an attempt is made to reconcile them with actual stock surveys.

In regard to the circulation of materials from process to process in the shops, a matter on which great claims have been set up by certain schools of management of late years, methods based on the principle of "what is happening" rather than on the idea that we can force things to happen will commonly give the most practical results. Neither method implies laxity or a "go as you please" atmosphere, but the first is obviously much less likely to tangle up than the second. Both methods should be applied graphically—that is to say, that at one or more points there should be control stations at which it should be possible to ascertain precisely the position of every component within the sphere of such station. Combined with the principle of "due dates" referred to in the third article, very close control on the movements of material should be maintained.

In some industries the question of "loading" is much more important than in others. By "loading" is meant the ascertainment of just how far the capacity of the factory is engaged ahead, and consequently what is the earliest date at which deliveries may be promised. This problem is one which has no general solution. In some cases it may be necessary to ascertain the loading of every individual machine, or at the other extreme, the capacity of the whole plant may be taken as one unit, and the loading merely ascertained as so many days' work per order, or so many orders per day. Some fifteen years ago I saw in Europe a very perfect system of controlling deliveries, employed by a firm making heavy machinery, in which the loading of the plant was indicated graphically and every week photographs were taken of the indicator. These photographs were placed in the hands of the travelling men, who were thus enabled to promise deliveries with accuracy and confidence. The nature of the product, however, lent itself peculiarly to this device, and it is not very generally adaptable.

Recapitulation

The chief object of planning in advance is to secure efficiency in things as they happen. Whilst a principal field of planning is the securing of co-ordination, that is, arranging that events should happen in the right way at the right moment, it also refers to the securing of as great perfection as possible in certain separate fields of effort.

Planning may usefully be carried out in the following departments of effort, viz.:—

(1) The design of components, both as regards their design for use and their design for manufacture; the careful consideration of how each component is to be made, and the design of the necessary jigs and fixtures to be used in making it. The process of designing a component can therefore be carried out, where necessary, or economically desirable, up to and including the specification of the operations and the class of machine to be used. But where this is the case, the design should not be officially adopted un-

til (1) it has been criticized by the shop officials and (2) where the work is of a small class, actually tested out by a department devoted to such verifications. No design should be regarded as having a sacrosanct character, but as tentative, until a better design has been suggested and accepted.

(2) The flow of materials. Since the character of the flow of work in a shop—whether it is moving in a thin, fast stream, or in irregular waves, being checked here and running short there—is a matter of the utmost economic interest, two things must be provided for. One of these is such a system of control over the stores, including the purchasing arm, that material shall always be at hand when required by the shop, and this should be arranged without locking up too great an amount of capital in materials. The other is that the loading of machines should be carefully watched. By "loading" is meant the amount of work that is required from each machine in reference to time. A "loading gauge" system should be adopted wherever the nature of the work permits, so that the future deliveries of each machine, barring breakdowns, may be predicted with sufficient accuracy. Attention to these two

points, if successfully applied, will go far towards ensuring a steady, fast stream of work throughout the plant, with an accompanying fidelity to promises of delivery.

The control of movements from process to process is best attained by methods which enable a graphic record to be set up at one or more control stations, such record being closely associated with "due dates" at which each stage of manufacture should be passed. Every failure to come up to expectations as to these dates is to be promptly followed up, and the missing material urged forward. Such a plan is simple, not liable to derangement, and independent of the working of other departments. The shop as a whole can be induced to take an interest in such an indicator, and to take pleasure in keeping ahead of the scheduled dates where these are carefully and sensibly allotted.

(3) The control of quantities. Based upon a careful study of the normal flow of materials, which is in its turn controlled by the loading capacity of the machines, a close grip on the question of quantities may be maintained. In some businesses this is much more important than in others, but still a large number of modern businesses are de-

pendent on producing varying quantities of regular products in such a way that orders can be fulfilled with fair promptitude, and yet but little finished stock is carried. The control of quantities, therefore, determines the character of the products actually occupying the shop at any moment, and therefore the possibility of meeting future demands in a reasonable period. Control of quantities is therefore an important part of planning, and its main secret of success lies in knowing just what the plant can do in a given time — that is, in other words, how much load each machine can bear in, say, a week. This in the first place is obviously a matter of arrangement with the commercial arm, for the settlement of a policy as to quantities of each kind of product which shall be produced periodically. They may vary from season to season in many instances.

(4) The observance of "speeds and feeds". This work should be considered not as a part of planning, but as belonging to the art and craft of metal working, in the case of a machine shop. If the knowledge of the right use of machine tools is at such a low ebb that the shop cannot be trusted in this matter, the remedy obviously lies not in an

involved and complex system which neither broadens nor seeks to broaden the operator's knowledge or experience, but in study of machines and training of machine operators. This is the only way in which the individual's psychological reaction with his work can be fostered and assisted—a reaction which is wholly ignored by those who wish to rule shop operation by rote. To admit that a man's nerves and temperament have any place in manufacturing operations shatters, of course, the whole position of the "planning department" fetish, but it will have to be admitted and recognized sooner or later.

In any case, a planning department should be concerned with the changeable events and affairs of routine manufacture and not with the fixed ones. If it is considered necessary to settle in advance not only the precise methods of manufacture, but the speeds, feeds, cuts, and time allowances, this is certainly much more closely allied to the designing function than to the planning function. Highly technical considerations are involved, but these considerations are not subject to variation in any arbitrary or sudden manner. *The manufacture of a component should be discussed, as mentioned above, at* *the time the design is being put into final shape. This is also the time to make intelligent comparisons, and consequently intelligent use, of speeds, feeds and cuts,* from which time allowances are a natural deduction. This kind of work may be specialized, of course, but it should not be made too independent or given greater authority or prominence than it deserves. Where it is necessary or advisable to do it at all, it should be considered as one of the elements of design for manufacture, *since it is entirely antecedent to all other planning operations—they follow it, it does not depend on them.* Finally, the whole question of the right use and understanding of machine capacity is involved here, as pointed out in Chapter XV.

It will be seen from the foregoing that the planning of shop work is the art of keeping things moving in an efficient way. It has nothing to do with the efficiency of design, nor with the efficiency of operation. It is one of the sub-departments of control and that particular sub-department concerned with movements of product. It controls the supply of the raw material, conducts it into the shops, and "loads" the machines with it —actual "planning" being the intelligent adjustment of the productive capacity of the machines to the work to be performed, time being a factor of the result. In its broadest sense planning has to regulate the organic relations of production centers, of the indirect services with these centers. It has to bring about *correct proportioning* of the different classes of productive activity, and to observe how they are being maintained and served. It controls necessarily all the stores and transport services, and if suitable records are kept and a competent man is in charge, very important observations as to when and where modifications in the lay-out and the transport arrangements are necessary should be forthcoming from time to time.

Appendix V

SOME AXIOMS OF ADMINISTRATION

1. Transfer of Skill
2. Interchangeability
3. Output and Cost
4. Burden and Cost
5. Capital and Cost

Appendix V

SOME AXIOMS OF ADMINISTRATION

1. The Transfer of Skill

SOME authorities have considered that the transfer, embodiment, or storage of skill which takes place when we design a machine to perform work hitherto done by skilled labor, amounts to a regulative principle in industry. This view was taken by the majority report of the American Society of Mechanical Engineers referred to in the author's Preface, and has been adopted also by Prof. Dexter Kimball,* who has provided an excellent illustration of the idea by considering the drilling of a number of plates with four holes in each,—it being requisite that the holes should correspond exactly in all the plates. This would be a task that would tax the skill of the best mechanic, and would also be a long and costly operation. But the skill possessed by the mechanic can be *transferred*

* See Principles of Industrial Organization, page 10 etc.

to a jig, and *stored* or *embodied* in it, so that any number of pieces can be drilled exactly alike by applying the jig to them. The drilling can be done by comparatively unskilled labor, and in a much shorter time.

Similarly, in many industries, including the textile trades and shoe manufacturing, the skill formerly exercised by the craftsman has not only been divided into a number of entirely separate operations, but has been transferred to, or stored and embodied in the machines themselves. Of course, in these instances, as in the case of the drilling jig, this does not imply that no skill at all is required to operate, but that a less degree of skill suffices. In some cases, however, as in the case of automatic screw machines, every particle of the original skill required to perform the difficult operation of hand-turning of screws, is transferred to the machine and stored in it. This is, in fact, the condition toward which all inventive progress tends.

As regards administration, however, it is very questionable whether transfer of skill can be ranked as a guiding or regulative principle. It is at any rate not a principle of universal application, like those already discussed. It is a tendency in *industry,* but not a rule of *administration.* As a matter of fact it has economic limits, which it is beyond our province to discuss here. We need only mention the fact that specialized appliances are dangerously subject to obsolescence, and that while it may be possible to make a jig, it is not always economically profitable to do so.

From the administrative point of view, therefore, no mandatory principle as to the transfer of skill can be laid down. We cannot rule that it should be employed in every case where it is possible to apply it. All we can say is that it can be applied, and therefore that the advantage of applying it should always be carefully studied, *pro* and *con.* These considerations lead us to place it, not as a Law of Effort, but as the first axiom of administration, in the following form:—

2. Skill Can Be Transferred to and Embodied or Stored in Appliances.

II. Interchangeability

Closely connected with the use of jigs, is the common problem of the interchangeable part. Here, again, we have a question that is by no means of universal application, for it applies only to particular classes of industries. We cannot speak of interchangeable sugar or pig-iron, but we can speak of interchangeable parts of a watch, a motor, or any other mechanism. Now the decision as to how far a manufacture shall be carried on on the lines of interchangeability is not, properly speaking, a question of administration at all. It is a question of policy, and belongs to the Determinative element in management spoken of in the preface. Interchangeability costs money, and this largely determines its application. To make parts of motors interchangeable may be worth while, to do the same for iron bedsteads or bureau drawers would be less advisable. It is no principle of *administration,* since we cannot put it in a mandatory form. We have not yet arrived at the point when we can say that interchangeability should always be aimed at, wherever physically possible. It remains, therefore, merely an axiom, the application of which must depend on circumstances which are commonly regulated by conditions of marketing outside the factory. This axiom can be put thus:—

3. Interchangeability of Parts Is Frequently Desirable.

III. Output and Cost

The question of the embodiment of skill in machines or certain auxiliary appliances like jigs, and that of interchangeability of parts, bears on another problem which is also largely bound up with questions of policy. In a general way, the more we concentrate our efforts on producing one line of product by specializing machines, introducing jigs and fixtures, and introducing mass production, the lower should be the cost per unit of product. In any industry, if we increase volume of output by improved processes or by improved organization, or by speeding-up production, the increase in output is generally greater than the increase in cost. In other words the unit cost falls. Prof. Kimball has raised this observed relation between increased output and lower unit cost to the rank of a principle* but we cannot here so regard it. It is a thing that does not necessarily happen. In many cases it does not happen. Cases are not infrequently met with where the expenditure on special appliances, if properly taken into cost, would neutralize the advantages gained

* See Principles of Industrial Organization, p. 251.

from their larger output. Moreover, just how far specialization should be carried out is not a problem of administration, but a policy of management. Some years ago the great demand for bicycles led to the adoption of a policy of specialization by numerous firms in that industry, and this was carried to such a degree that when the demand fell off, widespread ruin to the industry ensued. It is not the administrator's part to say that increased output should be reached by the path of specialization.

In minor matters, however, the decision whether the manufacture of a particular article should be made by means of jigs and fixtures is certainly an administrative affair. But in this case the point of view is generally that of attaining lower cost, without taking the question of output into account. It would seem therefore that to regard increased output as the cause of lower unit cost is putting the cart before the horse. Increased output *may* be accompanied by lower cost, but not necessarily so. On the other hand, the converse is true under nearly all circumstances—lower unit cost (except in the single instance that it is procured by a cut in wages or expense) must necessarily mean that manufacturing capacity is set free, or in other words that the *opportunity* for increased output is thereby provided. Whether or not the output is actually increased depends on other than merely administrative considerations. Lower cost does not always, though it does usually, imply in its sequence larger sales.

The connection between cost and output can therefore be stated in very simple terms, not as a regulative principle, but as an axiom of administration, viz:—

4. Lower Unit Cost Normally Implies Increased Capacity for Output.

IV. Burden and Labor Cost

We have now to consider another important aspect of the volume of work, namely, the relation of burden to direct labor cost. It is frequently assumed by executives that the lowering of burden percentages is necessarily a good sign, and that conversely if the percentage of burden to direct labor rises, it implies some kind of reduction in efficiency. *These assumptions have no validity as general principles, and are only true in particular cases. In other cases they are not merely* *incorrect, but actually the reverse of the facts.*

We may define burden as all the expenses of a shop (including a share of the general expense of administration), no part of which can be considered as direct labor. We have not to do here with the way in which this Burden is, or should be, distributed over individual jobs, but simply its relation as a whole to the total of direct labor as a whole. If we consider that the whole shop is engaged on one job, and that all direct labor is being charged to this job, and all burden collected and expressed as a percentage of direct labor, it will be sufficient for our present purpose. We may also make another assumption, namely, that during a given period all the machines were kept fully employed, and full time worked by all hands.

These assumptions are necessary because it is desirable to eliminate from our problem variations due to the plant not being fully employed, or to overtime being worked. We wish to consider the case of a shop keeping the same number of men and the same number of machines steadily at work for the same number of hours per day throughout the whole period of our observations.

TABLE XX. SHOWING HOW PERCENTAGE OF BURDEN TO DIRECT LABOR FAILS TO CORRESPOND TO VARIATIONS IN COST. (CONSTANT BURDEN.)

Item.	Output.	Burden.	Direct Labor.	Percentage.	Unit Cost.
1	1000	100	100	100	.20
2	1200	100	100	100	.16
3	800	100	100	100	.25
4	1000	100	130	77	.23
5	1200	100	130	77	.19
6	800	100	130	77	.28
7	1000	100	80	125	.18
8	1200	100	80	125	.15
9	800	100	80	125	.22

In our first series of observations the shop expense (including administration charge) remains at the same amount through the whole period. Table XX shows the effect on the percentage of burden to labor, of variation in other factors, namely cost of direct labor, and output. The first line of the table, Item 1, shows normal conditions with which all the other observations are to be compared.

Item 2 shows what happens when, with normal labor, and normal burden, the output is increased. Item 3 shows what happens when output falls off. In each of these cases the Burden percentage *fails to move at all.*

Items 4, 5, and 6, show what happens when an increase of wages is granted to direct labor. This of course, means that the total cost of production has *gone up,* but the percentage itself *falls.* It also falls to precisely the same amount whether the output remains the same or is increased or diminished.

Items 7, 8, and 9, show what happens if we make a general reduction of wages. This implies that cost of production is *reduced,* but the percentage, on the contrary, *rises.* It also is seen to rise to the same amount, whether output remains steady, increases, or diminishes.

In these three groups of observations we see that the percentage of burden to direct wages is a very deceiving thing. In the first group it fails to reveal important changes in output that have happened. In the second and third groups it behaves in an exactly opposite way to what it is popularly supposed to behave, and again fails to reveal important changes in output.

Table XXI shows another series of observations under different conditions. In this series the cost of direct labor remains level throughout all the observations, but the amount of expense varies, and so does the amount of output. Item 1, as before, shows normal conditions with which all the other observations are to be compared.

TABLE XXI. SHOWING HOW PERCENTAGE OF BURDEN TO LABOR FAILS TO CORRESPOND TO VARIATIONS IN COST. (CONSTANT LABOR COST.)

Item.	Output.	Burden.	Direct Labor.	Per-centage.	Unit Cost.
1	1000	100	100	100	.20
2	1000	120	100	120	.22
3	1200	120	100	120	.18
4	800	120	100	120	.27
5	1000	80	100	80	.18
6	1200	80	100	80	.15
7	800	80	100	80	.22

Items 2, 3, and 4 show what happens when expense increases. In this case the percentage does what it is popularly supposed to do in every case, namely, rises correspondingly. But Items 3 and 4 show on the other hand that this rise has nothing to do with output. In the case of Item 3, although the expense has risen 20 per cent, output has also risen 20 per cent above normal. Now the net result of this combination is not an increase in cost, but a *decrease,* yet the rising of the percentage would make us think that shop conditions were worse instead of better as they are in reality.

Items 5, 6, and 7 show what happens when expense decreases. Here again, the percentage behaves as popularly expected. But again, as shown by items 6 and 7 its behavior is independent of output. Item 7 shows a 20 per cent reduction both of burden and output, but the net result of this is an *increase* in cost, though the burden percentage itself has fallen.

In other words, the mere falling of the percentage would lead us to believe that things were going well, while actually costs were rising.

In this second series of observations we see, once more, that the percentage of burden to direct labor is a very deceiving thing. Its rise or fall corresponds to the real facts of cost only in the special cases *where the amount of output* remains absolutely steady. As soon as the efficiency of the shop varies, thus introducing a new relation between amount of output and the other factors, it becomes actually deceptive, and any deductions based on its rise or fall are wholly erroneous, and in some instances the very opposite of the facts.

This is not the place to discuss the alternatives to the percentage method of dealing with burden. They have been fully treated elsewhere by the present author*. The important point in this instance is to discover what relation of burden to cost is fundamental.

A little consideration will serve to show that if the ratio between burden and direct labor is one that has no relation to output, it can have no relation to efficiency. This leaves us face-to-face with the position that the only way to judge relative efficiencies is by comparing the *amount* of burden in unit cost A with that in unit cost B. Also the *amount* of direct labor in A with that in B (A and B being the cost of the same article made at different times or by different processes). But this consideration shows how absurd it is to calculate Burden as a percentage on direct labor, since by so doing we ensure that the *amount* of burden in A and B will always be proportional to the amount of direct labor in these respective

*See "The Proper Distribution of the Expense Burden," 2nd edition, 1913; also "Production Factors," 1910. Both published by The Engineering Magazine Co.

unit costs, although we may be quite aware that wholly different processes, entailing wholly different calls on indirect expense, have been used in producing A and B respectively.

Nevertheless while the practice of employing percentages to ''distribute'' burden continues its hold on the affections of executives who would shrink with horror from such a deceptive method if applied to their cash book, it is at least desirable to understand its limitations and the dangers that lurk in the popular ideas with regard to its significance. The next best thing to adopting an improved method is to understand the whole truth about a defective method, and this we propose to put in an axiomatic form.

An axiom being usually defined as a self-evident truth, it may be objected that to make an axiom of this somewhat intricate demonstration is stretching a point unduly. The truth would, however, be sufficiently self-evident were it not that the adoption of the percentage method, at first introduced as a book-keeping ''dodge'', and since erected into all the dignity of a working principle, has led to perverse habits of thought on this subject. Had the unlucky device of percentages of this kind been brought to notice only *after* a scientific method of distributing burden had come into regular use, its fallacy would have been self-evident enough. In the writer's opinion, at any rate, the matter is sufficiently clear after a little examination to warrant the true relation of Burden to Cost to be stated as an axiom for all practical purposes. It is therefore stated in the following terms:—*

5. The Amount of Direct Labor and of Burden in Unit Cost (and Not the Ratio or Percentage) Is Alone the Test of Efficiency.

V. The Influence of Capital on Cost

The proportion of capital employed in modern industry, whether reckoned per unit of product or per employe, constantly tends to increase. In some industries, in fact, its increase is rapid and continuous. Yet in these same industries the comfortable old ways of finding costs, without accurately tak-

* The author is indebted to Mr. H. L. Gantt for calling his attention to this subject, viz., the perverse behavior of burden percentages where unit cost is actually falling.

ing the incidence of capital into account, still goes on. It seems desirable to discuss the matter briefly, if only to establish the axiom that "capital is a factor in cost".

There is no difference in principle, and there cannot be safely made any difference in practice, between capital that is transformed quickly into something else, and that which is slowly transformed. With one exception, no capital is really "fixed", but only relatively so. When capital in cash is transformed into wages, the importance of connecting wages with the "cost" of work is recognized by everyone. But when it is transferred into such various things as patterns, files, emery-wheels, steam-engines and dynamos, and heavy productive machinery, it has the appearance of being more or less "fixed"—slightly so in the case of a file, which wears out a little while you watch it, but very much so in the case of a steam engine, a punching machine, a large crane, or a factory building of steel and concrete.

Actually, however, when capital is transformed into any of these things, it is no more really fixed than when it is in the form of a file. With one exception, and that exception is land, there is no form of capital investment that does not begin to decay and perish from the moment of its completion, and one day come to the state in which it is no longer useful for the purpose for which it was created.

Even the exception of land, above mentioned, is not a universal exception. Where land is held on a terminable tenure, for a term of years, its value is constantly shrinking like Balzac's magic skin, and this shrinkage begins from the moment the lease is signed. Generally, however, land value is not subject to decay, since land does not rust, it does not wear, nor as a rule does it become obsolescent. In many cases, indeed, it tends to increase in value, if in the neighborhood of cities.

All other forms of capital tend to disappear. If a plant were started today, and no part of it were renewed, in thirty years the greater part of it would be as valueless as if it had never existed. The finer the kind of plant the more complete its exhaustion, or to put it another way, the earlier the period of valuelessness would be reached.

To begin with we have active capital, in the form of cash. This is transmuted into various things, plant and machinery amongst others, and at the end of a given period nothing remains but scrap value. *Where has this capital gone?*

The answer to this question is coming to be a controlling one as regards costs of manufacture because the progress of industry demands a constantly increasing proportion of capital locked up in "fixed" forms. There can only be one answer—namely, that since the whole object for which the capital was spent and the plant established is the making of product, it is evident that this capital has been exhausted in producing goods, or in other words, *the original capital has been transformed into product.* The only exceptions to this are the scrap value of the exhausted plant which remains on our hands, the "spoiled" product which had no commercial value, and the loss incurred when the plant or any portion of it lay idle.

When we pay wages, whether piecework or daywork, the process is easy to follow. We take so much out of our capital in bank, and pay it to the man in exchange for so much product. We say that that amount of product has "cost" that amount of wages. The transaction is over and done with in a few moments.

But how much of our so-called "fixed" capital have we used up in producing that same amount of product? If the man has used up a file on a job, we follow quite easily the idea that the part of our capital represented by the file has passed into the job. But what share of all the great capital investment represented by the plant and buildings passes into the product hour by hour?

If this capital passed into all jobs in equal proportion the matter would be quite simple to deal with. But this is, in most cases, very far from being the case. Jobs call for different machines and these machines not only represent great differences of capital in themselves, *but they make demand in very different proportions on the other forms of fixed capital invested in the group of organization.* Different shares of floor space, of the power service, of the cranage and transport service, etc., are called for according to the nature of the job.

Nor is this all. As all capital tends to decay, so is it necessary to repair it. Also, for the most part, it requires living attendants to enable it to perform its functions. The power service has a whole group of attendants, the buildings must be repaired, kept clean, heated and lighted, cranes must be manned, and so forth. So that it is not only the capital locked up in organization services that has to be reckoned with—*there is also all the expenditure associated with its upkeep and functioning.* Each of these important groups of expenditure has its separate influence on the working power of machines, and each machine absorbs their assistance in different proportion.

Taken together, these items made a formidable total in the cost of running machines. But the essence of the argument is that some machines should bear much less of this cost than others. They make less demand on the capital invested in the Production Factors, and on the services and maintenances connected therewith, than other machines, and *this difference is quite as large in range as the difference between the wage rates of the labor employed in the shop.*

How then can we know the true cost of a job unless we know both the machine cost and the labor cost? The capital we employ in paying wages is charged to jobs according to the exact sums we have taken from our capital and spent in wages on those jobs.

But the interest, depreciation, maintenance and service on the capital expended in everything else but wages is not charged to jobs according to the exact sums (represented by the machine rent) which have been expended on those jobs, but by some "easy" method of percentages, whose only function is to make ignorance look like knowledge.

To sum up this question of capital. Every day so much of our "fixed" capital disappears out of the plant, *and carries with it all the expenses for its upkeep and functioning.* In amount it is an enormous percentage of the total cost, rarely less than 75 per cent on labor, and no system of costs can possibly be true which does not account for this expenditure *as and where it is incurred in different proportions by different productive machines.* For, as has been said before, the whole object for which this investment of capital is incurred is to keep productive machines at work, so that they may turn out Product.

Mention has been made, in the foregoing discussion, of the machine alone. In fact the salient feature in modern production, if only we regard it from the right standpoint, is the expense of machine operation. But as, in all plants of the assembling industries, there are men who do not use any machines, their existence cannot be ignored. Actually, however, we find that the existence of direct productive labor engaged on processes which do not call for machinery, alongside labor that does, makes the argument a much stronger one—for such men make hardly any claim on capital investment at all. Very little of the capital invested and maintained in the organization services goes into their work.

In all cases they call on the land-buildings and the heating and lighting services, but beyond this they make little or no call on capital. Yet in most plants, their particular work is loaded up with burden in the same proportion as work done on the most expensive machine in the place, using the most power, taking up a large floor space, and calling for heavy transport services. The peculiarly illogical character of this kind of costing must be self-evident. There is no pretense to accurate ascertainment of the influence of capital on production of such a system. As a by-product, the comparative costliness of doing special work by hand and rigging up a machine for doing it is impossible to ascertain. It is a splendid method for hiding facts, and getting inaccurate results, when it would be just as easy to observe the true incidence of capital in every operation, however carried out.

The first line of control is, then, to record and thus to watch over the various transmutations of capital that are going on from day to day. Provided that each change in the form of capital comes at the right time and is in the right direction and the right amount, profits will be in proportion to the speed at which these transmutations take place. In other words, as pointed out in another place, a fast-moving stream of work is the ideal condition in a factory. Dividends are dependent not merely on profits, but on profits made within certain limits of time. The factory that turns out product yielding say $1,000 profit in six days will be ahead of the similar factory making $1,500 profit on the same output, but (perhaps by using cheap, slow labor) taking twelve days to do it.

Slow turning over of capital is one of the ways in which profits are diminished, but in such cases the capital does actually reappear. But another cause of diminished profits is the failure of capital to reappear at all. It gets transmuted into forms that cannot be made further use of, or only partially so, as a spoiled casting on which considerable machining work has been done, or a faulty rubber product that has already been vulcanized. Such happenings are known as ''wastes'', and are a more prolific cause of reduced profits than is commonly realized until very exact measures are taken for their detection.

Hitherto, the influence of capital on production has been but little regarded, though the analysis of the manufacturing census recently published in *The Engineering Magazine* by Mr. A. G. Popcke shows how important a matter it is getting to be. Briefly, Mr. Popcke showed that the capital employed in production has, on the average, increased during the brief space of ten years, 20 per cent more than the value of the product has increased. How far this is due to actual increased investment in the factors of production is shown by the further fact that over 40 per cent more horse power per individual operator is required to drive machines than ten years ago.

Speaking generally this means larger and more powerful machines, entailing larger floor space, increased call on shop transport services, and these of a higher type, and a call for capital in the indirect services or organization on an increasing scale. This general call for increased fixed investment is confirmed by the fact that capital investment has increased 46 per cent per man employed in ten years. The importance of regarding the activities of a plant as a series of changes in capital seems to be fairly proven by these remarkable figures.

In all businesses in which the product is not uniform, but consists of different kinds of articles, each made by different sequences of machine work, and taking different quantities of such machining, the influence of capital is very much greater than generally suspected. In many instances it may have a controlling influence upon what should be regarded as the real cost of the different items of product.*

We have now seen that every act of manufacture implies a corresponding conversion of fixed capital into product, and that this issue cannot be evaded without producing

* The *methods* by which capital is permitted to have due influence in cost have been covered in the author's books on the Expense Burden and on Production Factors.

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